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# Agent-based modeling of the social and economic factors affecting the choice of transportation mode: application to the Beirut city

Samar El Amine

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**THÈSE DE DOCTORAT DE L'ÉTABLISSEMENT UNIVERSITÉ BOURGOGNE FRANCHE-COMTÉ  
PRÉPARÉE À L'UNIVERSITÉ DE TECHNOLOGIE DE BELFORT-MONTBÉLIARD**

École doctorale n°37  
Sciences Pour l'Ingénieur et Microtechniques

Doctorat d'Informatique

par

**Samar El-Amine**

**Agent-based Modeling of the Social and Economic Factors  
affecting the Choice of Transportation Mode:  
Application to the Beirut city**

Thèse présentée et soutenue à Belfort, le 11 décembre 2018

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I dedicate this work to my beloved and great father who is part of my soul, and to my precious and tender mother.



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It was Rousseau who stated that gratitude is a duty, which ought to be paid. It is in line with this fundamental truth that I construct some words of thanks to those whom they are due. First of all, I would thank God Almighty for giving me strength and knowledge to work on this dissertation. Knowledge is His nature and I am indebted to Him for giving me a share of it.

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## ABSTRACT IN ENGLISH

This research elaborates the importance of public transportation in urban cities like Beirut. Many studies have been used as reference that demonstrated the importance of public transport on public interest, for example by preserving the environment, reducing congestion and reducing the operational costs of transport in general. It highlights the current situation of public transportation in Lebanon and understanding people's choices in using different transportation tools during their daily movements. The research aim to identify and measure the parameters and causes that form the behavior of people and reflect their choices in the usage of miscellaneous road transport. Defining the parameters will help the decision makers to take actions for maximizing the usage of public transportation in the country.

This research displays a unique agent based behavioral model based on the socio demographic situation of the study region. The concept uses UML diagrams that explain the connections between agents and parameters. Agent-Based modeling has developed a vital factor for performing prediction-based scheduling, such as the transportation models for municipal cities. Agent Based Modeling and Simulation (ABMS) is a modeling method for aping the activities and connections of autonomous entities, with a vision of evaluating their impacts on the system all together. ABMS has been linked to a wide scope of spaces in transportation. These applications fundamentally fall into two procedural ideal models: individual-based models that analyse individual transportation-related movements and behaviour, and computational strategies that analyse a community oriented and receptive transportation outline that displays insight by representing a gathering of sovereign basic decision-making of subsystem materials called agents. Connections between the agents in the system are established, environmental variables are set, and simulations are run. The prior is decisively identified with the models for travellers' movements while the latter is usually examined as a computational plan in a distributed artificial intelligence (DAI) outline, or a complex adaptive system (CAS), which is a skilled procedure for imitating dynamic complex outlines to watch new performance. Not to forget the ideas recognised to the social behaviours in combination with the agent-based modelling procedures. OVG survey was conducted in Lebanon for data collection and Multinomial logistic regression was employed to analyze the data.

The major findings are elaborated from the data analysis. The research considered many factors and derived five major themes out of them i.e. car usage as driver, car usage as passenger, bus usage, taxi usage and work school transportation usage behavior. The research findings of the study clearly show that occupation and status in management play a role in the choice of transportation. However, their role different in the choice of transportation is different. To see which factors are of vital importance, we kept in mind various dimensions and computed variables that are more significant.

This research gives a very clear picture of the public transportation system of Beirut and can be of great help to analysts and planners in modifications in how to improve the system and to attract people in using more public transportation than private transportation.





## RÉSUMÉ COURT EN FRANÇAIS

Au sein des environnements urbains et péri-urbains, le transport et la mobilité sont fortement liés aux activités socio-économiques. Ils sont influencés et affectés par la psychologie personnelle de chaque individu, les normes sociales, la résistance au changement, l'attitude personnelle, les habitudes, les peurs et les croyances. Ainsi, les individus constituant la population dans un environnement urbain choisissent d'utiliser les modes de transport durant leurs déplacements quotidiens en fonction de ces diverses influences. La mobilité et l'accessibilité aux lieux sont considérées comme essentielles pour mesurer la qualité de vie dans nos villes. Toutefois, il est communément admis que la topologie de nos villes possède une profonde influence sur cette mobilité et cette accessibilité. Cette thématique est au cœur de nos travaux de recherche. Ainsi, Beyrouth est une ville mono-centrique qui fait face à un problème de pauvreté de l'offre de transport. La possession de véhicules a rapidement augmenté pour répondre à la pénurie de transport public (Macal et North, 2010). Actuellement, il existe une opportunité de développer dans cette ville les services de gestion de la mobilité et d'y établir une mobilité et une accessibilité durables. La mobilité urbaine durable exige que les modes de transport soient abordables, efficaces et respectueux de l'environnement, avec une pollution atmosphérique et auditive minimale, ainsi que des technologies permettant de minimiser la consommation énergétique des moyens de transport. L'objectif de tels systèmes de gestion de la mobilité est de minimiser les coûts des déplacements. Cela est possible en mettant l'accent sur trois points principaux: réduire les besoins de déplacement, adopter des modes de transport plus respectueux de l'environnement et améliorer l'efficacité de la technologie et du transport des véhicules. De plus, cet objectif sera atteint en mettant l'accent sur l'accessibilité et non pas simplement en augmentant l'infrastructure routière. Cette thèse porte sur la modélisation des comportements de déplacement, basée sur la modélisation orientée agent, et prenant en considération la situation socio-démographique de Beyrouth. Nous avons analysé les données obtenues à partir d'une enquête que nous avons réalisée pour la ville de Beyrouth. Nous avons établi une relation l'emploi, le statut social et la sélection du mode de transport. L'attitude des usagers devient différente quand ils gagnent plus de revenus ou s'ils ont un statut supérieur dans le contexte de la gestion du trafic. Ils évitent les transports en commun et essaient d'utiliser leur propre moyen de transport privé. L'objet de la thèse est un modèle de simulation orienté agent du trafic routier en utilisant une approche économique institutionnelle. Nous proposons une architecture, des algorithmes et des méthodes pour implémenter le modèle des agents afin de modéliser et de reproduire leurs comportements de choix de modes de transport. Le but du travail est la création d'outils et de techniques qui garantissent l'utilisation de la simulation d'agents pour l'étude de schémas d'organisation du trafic. Pour atteindre cet objectif, les tâches suivantes ont été résolues dans le travail:

1. Comprendre les moyens de transport accessibles à Beyrouth et les présenter de manière simple et compréhensible.
2. Déterminer dans quelle mesure les facteurs économiques tels que les impératifs financiers, l'inflation croissante ont un impact sur le choix du mode de transport.
3. Mesurer le degré auquel des facteurs sociaux tels que le niveau de vie peuvent influencer le choix de l'homme dans le choix d'un mode de transport spécifique.
4. Examiner l'effet que des facteurs innés peuvent avoir sur une personne au fur et à mesure qu'il adopte un mode de transport spécifique.
5. Comprendre l'effet que le choix privilégié d'un mode de transport a sur le sort de la population à Beyrouth.
6. Créer un modèle de simulation orienté agent des usagers de la route pour Beyrouth.
7. Proposer une méthode permettant de simuler le comportement des usagers en cas de congestions ou d'événements survenant à Beyrouth.
8. Développer un progiciel implémentant le modèle d'agent proposé.

Les questions scientifiques associées sont :

1. Les facteurs économiques jouent-ils un rôle important lorsque les individus décident de choisir un mode de transport?

2. Les facteurs sociaux (installations, niveau de vie) jouent-ils un rôle décisif dans la décision des individus de choisir un mode de transport?
3. Les facteurs de carrière (salaire plus élevé, distance entre le domicile et le lieu de travail, emploi permanent / à temps partiel) jouent-ils un rôle moteur lorsque les individus décident de choisir un mode de transport?
4. Les facteurs du ménage (taille de la famille, revenu du ménage, âge des membres de la famille) jouent-ils un rôle moteur lorsque les individus prennent la décision de choisir un mode de transport?

La modélisation basée sur des agents est de plus en plus utilisée dans les sciences du transport. Elle permet de développer plus efficacement des outils de planification et de prévisions, comme les modèles de gestion des systèmes de transport urbain. La modélisation et la simulation basées sur les agents (ABMS) est une méthode de modélisation permettant la modélisation et la reproduction des activités des entités autonomes et de leurs interactions, tout en ayant pour objectif de mesurer l'impact sur le système (Ortuzar , Willumsen , 2011). Les travaux de cette thèse s'intègre dans un projet de la société S&A (Belgique et Liban) visant à fournir les outils théoriques et technologiques afin de permettre la transition de l'usage des moyens de transport vers une pratique plus respectueuse.

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# CHAPTER ONE

## Introduction





# CHAPTER ONE: INTRODUCTION

## *1. INTRODUCTION*

This research has been done under an agreement with S&A Company based in Belgium and Lebanon. The company was seeking a research to understand why population of most of the European countries, particularly Belgium, prefer to use the public transportation, whereas population in Lebanon tend to incline more towards using personal transport over public transport. Hence, the researcher was given the task to find the factors that influence the decision of road users in choosing a particular mode of transport.

The results of the research will be shared with the Lebanese government to change the flow of usage from private to public transportation.

### *1.1 TRANSPORTATION BEHAVIOR IN BEIRUT*

Traffic congestion has long been a subject of trepidation in Lebanon. Less availability of public transport is considered a major contributor to this setback. Car ownership has grown rapidly to supply in the shortage of public road transport (Macal & North, 2010). Traffic congestion caused by the extensive use of private transport has not only caused cost of efficiency but has added to environmental hazards as well, especially the depleting air quality caused by pollution from carbon emission. Therefore, it is necessary to promote and support the use of public transport in minimizing such congestion (Holmgren, et al., 2012)

This PhD thesis would focus on agent based behavioral model based on the socio demographic situation in Beirut. The concept would be presented with diagrams that explain the connections between agents and parameters. Now, scientifically speaking, Agent-Based modeling has been around us for reasonably some time now and has thus developed a vital factor for performing prediction-based scheduling, such as the transportation models for municipal cities. Agent Based Modeling and Simulation (ABMS) is a modeling method for aping the activities and connections of autonomous entities, with a vision of evaluating their impacts on the system (Ortuzar, Willumsen, 2011). ABMS has been linked to a wide scope of spaces in transportation such as route choice behavior. These applications fundamentally fall into two procedural ideal models: individual-based models that analyse individual transportation-related movements and behaviour, and computational strategies that analyse a community oriented and receptive transportation outline that displays insight by representing a gathering of sovereign basic decision-making of subsystem materials called agents. In the mobility system, the entities may be shopper, student, internal tourist or any external tourist. All of these classes of a person have their own properties and their own behaviours (Ben, Huang, Zhuang, Yan, 2013).

An important aspect of the analysis of the functioning of the economic and social behavior factors affecting choice of mode of transport in Beirut is the finding of initial assumptions that determine the

behavior of the key category of people in the transport market-individual passengers in Beirut. Transport behavior of passengers is the primary factor that determines the activities of transport companies and other market participants involved in transport services. Provision of transportation services is effective only if the consumer buys a set of market services for him and pays it in due time at the current market price (Crooks & Heppenstall, 2012). The very category of "transport behavior" requires a theoretical description and justification, since it fundamentally differs from the concepts often used in the theory of urban public transport "transport mobility", "mobility", etc. A large study on the relationship between key terms of transport sphere is given in. We rightly points out that the PhD research of transport behavior is aimed at finding the answer to the question, why should people move by a specific mode of transport or on a specific route. In this case, the movement event itself occurs after the event, which initiates the origin of the target of the movement. The hierarchy of the sequence of such events can be represented as transport behavior (Crooks & Heppenstall, 2012).

## *1.2 ECONOMIC STUDIES FOR TRANSPORTATION BEHAVIOR*

Numerous economic studies show that people in some cases are not able to make optimal decisions in their economic behavior. One of the first researchers of irrational behavior of individuals was the author of the theory of limited rationality, the American scientist G. Simon, who pointed to the existing irrationality of individuals' behavior and attempted to explain this phenomenon. In his opinion, people as economic agents use heuristic analysis, rather than formal optimization. Most situations of economic choice are complex, and it is impossible to accurately take into account the usefulness of each action, therefore the decisions made can be irrational. Now, the theory of consumer behavior is being studied by economists who adhere to institutionalism and neoinstitutionalism (Crooks & Castle, 2012). The institutional theory has gained wide acceptance in the field of commodity marketing, but in the field of transportation services, in our opinion, research is not enough.

## *1.3 APPROACHES OF TRANSPORTATION BEHAVIOR*

We compared different approaches to the description of economic incentives and behavior patterns of passengers on public transport in the context of a comparison of classical and institutional approaches.

### *1.3.1 CLASSICAL ECONOMIC THEORY*

Classical economic theory is assumed that goods and services are exchanged directly or with the use of money only if their value is equal, and the buyer always tries to minimize their costs. For urban travel of passengers, this means that the passenger must use the mode of travel that has the minimum cost of traveling to the required distance while providing the desired ride comfort and quality of transport services (Crooks & Castle, 2012).

In reality, this choice usually does not occur; passengers often use the services of a taxi or a personal car, although the cost of a trip in this case can be tens of times greater than the cost of a similar trip in public transport (Crooks & Castle, 2012). Thus, within the framework of classical theory, the key contradiction for the sphere of public transport is the significant gap between the cost of the transport

service and its utility for a specific individual; currently there are no theoretical explanations on how to overcome this contradiction.

### 1.3.2 INSTITUTIONAL ECONOMIC THEORY

Institutional economic theory has gained considerable popularity now, explains the behavior of passengers. T. Veblen voiced key ideas of institutionalism more than 100 years ago. Institutional theory developed in the works of Commons, Mitchell, Pierce, etc. The basic premise of the concept of institutionalism is that the functioning of individuals occurs in a specific environment formed by institutions (McKerlich, Ives, McGreal, 2013). A separate institution means a set of rules that determine and regulate the actions of individual economic entities. Such rules arise from the organizational, national, social, cultural properties, qualities, forms and mechanisms of society (Ghorbani, et al., 2014).

Any society creates its own institutional environment in which economic agents interact with each other. Interaction manifests itself in the form of the assimilation of habits, recommendations, rules and standards of behavior in the developed economic conditions. Unlike the classical approach, institutionalism does not mean that a single individual is trying to achieve the maximum rationality of his behavior. The economy of institutionalism is based on the assumption of the possible adequacy of an optimistic approach to the study of human behavior, although in most situations this is not so. In many cases, the subject does not perform an accurate calculation to ensure the maximum effectiveness of his choice, and relies on existing traditions, his experience or comes from the acquired habits (Macal, 2016). The ability to rely on institutional rules simplifies the behavior of individuals, even if they are confronted with optimization problems. The widespread application of habits and laws transforms the task of rationalizing the behavior of the individual in the task of choosing one of the possible alternatives (Ascensão, et al., 2013).

### 1.4 HABITS AND RULES

Habits are the usual manner of behavior while rules are the instructions to what is allowed and what is not allowed. Habits can be preinstalled or acquired, and rules - conditional or unconditional. Following the rules forms a habit. Rules are usually broken more easily than habits, since habits take root at the subconscious level and usually do not lend itself to rational analysis. With a known set of alternatives and a resuming selection situation, it is possible to use simple procedures for finding the optimum by applying ready-made solutions. As a result, this behavior can be even more beneficial than the precisely calculated optimal, since it saves the time and energy of the decision-making individual. For example, in the field of public transport, when deciding on the choice of mode of transport and the route for commuting, the passenger must first calculate the effectiveness of alternatives to various modes of travel and only then make a choice. A more natural way of making a decision in this situation is following habits, for example, using the mode of transport that is near the place of residence. A similar habit is instilled in the subject through repeated repetition of the original choice. The passenger will continue to use the chosen mode of travel, while such a choice provides a satisfactory, from his point of view, efficiency.

In conditions of limited time, the individual cannot process all the necessary information required for choosing the mode of movement (Ascensão, et al., 2013). The adoption of an optimal solution in this situation is quite complicated, in this connection the passenger resorts to intuitive solutions. There is also the possibility of using ready-made solutions taken by other passengers in the course of a similar choice. The problem of rationality of choice arises in the individual, if the complexity of the information being processed or its uncertainty exceeds its cognitive abilities.

The complexity of information often leads to its misunderstanding and creates uncertainty. The emergence of uncertainty is due to a lack of information or the presence of inconsistency in it and involves the inability of an autonomous agent to process information in full. In this case, the individual allocates a piece of information, the most important, from his point of view, for making a specific decision.

In the municipality, there is a variety of options for moving, and the passenger chooses the permissible, in his opinion. This may not be the best method, but this approach is typical for one-time moves in new conditions for an autonomous agent. Autonomous agent is an intelligent agent operating on an owner's behalf but without any interference of that ownership entity. Summarizing such behavior, institutional economists point out: the very fact that individuals develop rules and follow them does not mean that they do not behave rationally. It is only expected that rules are formed out of reasonableness, and consequently, the use of rules raises utility (Hamill, Gilbert, 2015).

When a rule is created because of many repetitions of the choice of a solution in close situations, such a rule can only be obtained because of the rational outcome of most such repetitions. In the opposite case, the behavior of the subject can be changed and a new rule will not be formed. There are also examples of developing irrational rules. For example, mobility studies of economic and social behavior factors affecting choice of mode of transport in Beirut show that movements on personal cars have a disproportionately larger share than would be due to economic considerations. Moreover, the extra costs, compared to public transport, often outweigh the convenience, prestige and comfort of such displacements, although such "rationality" can be explained not only by economic reasons. Compliance with the rules and economic rationality usually do not conflict with the mechanisms of choice of rational consumer behavior, which is developed through natural selection among rational and irrational solutions with repeated repetition (Gaube, Remesch, 2013).

Rationality in the economic and social behavior factors affecting choice of mode of transport in Beirut should be understood in the generalized sense. Within the framework of the institutional theory, such a generalization means that not only the direct costs of the subject are minimized, but also its transactional costs. Transaction costs are understood as losses of the subject, connected with the process of making a choice. This is an additional cost to purchase a service. In a generalized sense, we can assume that transaction costs are an additional service that a consumer buys in order to receive a basic service. Thus, transaction costs in the public transport system are related to the time losses and direct financial costs of the individual to make a choice of a decision. For example, if you compare the costs of moving on a personal car and on foot travel, then we can assume that the subject saves time using the car, but at the same time carries additional financial costs for the use of the car. The ratio of these financial costs to the financial estimate of timesavings will also express the transaction costs of choosing a car. The emphasis in using the theory of transaction costs for the public transport

system should be aimed at using a comparative approach where transaction costs are considered only in their relationship to each other (Ronald, Thompson, winter, 2015).

Research has developed the concept of a model that describes the transport behavior of passengers in the transport system of the municipality based on an institutional approach. The model allows investigating the processes of management optimization in such a system. The use of optimal control of transport flows for the nodes of the transport network, especially during hours of increased passenger traffic, is a logistical task in modern conditions. Since the solution of such a problem significantly complicates the presence of a large volume of a priori information and uncertainty in the behavior of individual passengers, the most effective models and methods of system dynamics and heuristics will be most effective here.

### *1.5 EXPECTED RESEARCH OUTCOMES*

Taking into account the above theoretical considerations, we propose to use the institutional approach to modeling the behavior of passengers as autonomous agents. The model uses criteria to minimize the number of transport delays and increase the average speed of passengers' travel (Shakshuki, et al., 2013).

It is proposed to develop a model based on the agent approach. Unlike the classical approach, the agent does not require the use of top-down design and allows you to determine the behavior of the model directly in the process of interaction of its constituent autonomous agents. In this case, it is possible to achieve a local synergistic effect, when the agents self-organize to implement optimal and rational behavior. The choice of multi-agent systems as a modeling tool is justified by the effectiveness of their application for building models of collective behavior and describing the functioning of transport and logistics systems. There are several common processes for constructing agent models used for dynamic route determination in transport systems:

- ✓ Formation of a unified knowledge base on the transport system based on the analysis of input and output data;
- ✓ Definition of the logic and goals of the behavior of intellectual agents;
- ✓ The construction of regression dependencies for determining the logic of interaction of sets of agents;
- ✓ Choice of target functions describing the logic of agent behavior.

Using a single agent database provides the ability to build models that describe the behavior logic of a single agent rather than a group of agents of the same type. This approach is based on the assumption that agents have a similar set of characteristics, and, falling into similar conditions, will behave in the same way. Because of this grouping, the modeling results are significantly improved by predicting the dynamics of the movement of individual groups of agents. This makes it possible to use only the information for the previous period as initial data, which reduces the computational complexity of the constructed model (Watkins, et al., 2015).

In our model, a software agent acts as a modeled object (an individual passenger), who makes decisions about his behavior and himself chooses a trajectory of movements along the transport network. The basic version of the simulated system includes the route planner of an individual

passenger; a transport-modeling module that describes the route plan; congestion of the flow, as well as additional modules that implement feedback and interactions between individual agents.

The functioning of such a model is realized using the exchange of events between individual agents; the exchange of events takes place through the environment. Unlike centralized models with a single planning and management center, the approach chosen by us allows individual agents to adapt to external conditions and change their behavior taking into account the current state of the environment.

## *1.6 AIMS OF THE PHD THESIS*

This research is aimed to investigate the economic and social behavior factors involved in preference of usage of a certain mode of transport.

### *1.6.1 OBJECTIVES OF WORK*

The object of the Phd thesis is the simulation model of the agent-participant of the road traffic. The subject of the PhD thesis is the architecture, operation algorithms and methods for implementing the model of the agent-participant in the movement. The purpose of the work is to present the basic motives in choosing a specific mode of transportation in Beirut. To achieve this goal, the following tasks have been solved in the work:

1. To fundamentally comprehend the methods of transport accessible in Beirut and to exhibit them in a simple and understandable way
2. To gauge the degree until which economic factors like financial imperatives, expanding inflation, and so on an impact a man's choice of mode of transport.
3. To measure the degree until which social factors like standards of living, can affect a man's choice in choosing a specific method of transport.
4. To survey the effect that inborn factors may have on a person as s/he settles on a specific method of transport.
5. To investigation the wonders and understanding the effect that the favored choice have on the fate of street populace in Beirut.
6. To create an extensible simulation model of a road user agent for Beirut.
7. To propose a method to simulate the behavior of road users in the event of obstacles on their way in Beirut.
8. To develop a software package that implements the agent model used for low-level simulation of transport system in Beirut.

## ***1.7 THE RELEVANCE OF RESEARCH***

The increasing traffic flows in Beirut dictate the need to reconstruct existing ones and create new transport nodes. Various methods are used to assess the efficiency of transport construction. The study of transport systems using simulation models is becoming more widespread due to the flexibility and visibility of the results obtained. Similar studies can be conducted in municipal government institutions and design organizations in the development of transport systems. In addition, simulation transport models are sometimes parts of larger models of business processes of enterprises. In this case, the tasks of transport modeling may arise in front of companies providing technical consulting services. Depending on the scale of the modeled system, the scale of the model is also chosen. High-level models consider the flow of machines as a continuous value and operate with aggregate characteristics of transport infrastructure objects. In turn, low-level models reflect the behavior of each participant in the movement. An agent approach is used to construct such models (Chang, 2013).

In modern Lebanese city of Beirut, the difficulties in the movement are of a local nature and are due to resynchronization of traffic signal regulation, the absence of junctions on loaded intersections and. etc. Therefore, now the most relevant is the study of individual problem areas of roads. Low-level agent simulation models most adequately reflect the behavior of small transport systems, take into account their features and therefore are of the greatest interest.

Thus, it seems expedient to develop and implement a model of the agent-participant of the movement, which can be used as a basis for a decision support system based on low-level simulation modeling. The creation of such a system will allow to propose options for organizing and reorganizing road traffic schemes, to justify the expediency of decisions made and, as a result, to reduce costs when designing transport infrastructure facilities. In particular, the model will create a method for assessing the effectiveness of changing traffic control at intersections, which is relevant for the streets of Beirut.

Research Question:

1. Do economic factors act as an important contributor when individuals make the decision to choose a mode of transport?
2. Do social factors (Facilities, Standard of Living,) play a decisive role as individuals make the decision to choose a mode of transport?
3. Do Career factors (Higher salary, Distance from home to work, Permanent/Part time job) act as a driving force when individuals make the decision to choose a mode of transport?
4. Do Household Factors (Family size, household income, ages of family members) act as a driving force when individuals make the decision to choose a mode of transport?



## ***1.8 CONTENTS OF THE PHD DISSERTATION***

The introduction gives a general description of the work, the relevance of the PhD thesis is justified, its goals and tasks are given. The scientific novelty of the obtained results is shown, as well as the prospects of their practical application. In the first chapter the basic concepts are given, the review of works on a theme of research and existing tools of low-level modeling of transport systems is given. Transport system is a section of the road network and associated infrastructure with vehicles moving along it-participants in the traffic. A low-level study of the transport system involves both determining the characteristics of the system itself (throughput, maximum flow rate, average flow density, etc.) and calculating the values related to traffic participants (number of rebuilds, idle time in traffic, average route speed). There are two approaches to constructing 4 low-level models of transport systems.

Modeling of traffic with the help of cellular automata is based on the assignment of discrete rules of behavior of the model that operates with integers. The simulated section of the road is divided into sections of a certain size - the cells. Each cell can be in one of a finite number of states. Time is also sampled at finite intervals. However, models on cellular automata have a number of significant limitations, the main of which is the impossibility of monitoring the state of an individual participant in the movement. Another approach to the study of transport systems is the construction of models with a variety of agents moving in a continuous space. An important feature of agent models is that their behavior is the result of the interaction of agents, which are understood as software entities modeling road users. In view of the fact that the logic of the behavior of the agent-participant of the movement is rather complicated and includes stochastic elements, one can speak about the impossibility of replacing the agent model by some system of computational analytical models (Schneider, 2013). Therefore, the modeling of road transport by means of an agent approach has become widespread.

Based on the results of the analytical review, a conclusion is made about the expediency of developing and implementing a model of a participant agent of the movement. In the third chapter, the proposed model of the agent-participant of the road traffic is considered.

The large amount of heterogeneous information and the complexity of decisions made by the driver inevitably lead to the practical impossibility of creating a single algorithm of agent behavior. It seems advisable to divide the algorithms of agent behavior into several levels. The criterion for the allocation of levels is the frequency of decision making, which in turn depends on the rate of change in the state of the environment and other agents.

The decision at the strategic level consists in constructing a route (a sequence of roads, intersections, etc.) from the current location of the agent to the Destination using the transport system graph and information on the congestion of its sections. At the vertices of the graph of the transport system are the connection points of the sections corresponding to the positions of the agent's behavior change at the tactical level. The edge of the graph is a section on which the behavior algorithm of agents remains constant (Pike, Lubell, 2016).

Modeling based on the user-defined structure of the transport system. The tactical level is responsible for the behavior of the agent between the connection points of the sections. At this level, the problems of constructing algorithms for choosing the preferred lane, reconstructing and following the leading agent are solved.

Let the agent need to follow a certain section with several lanes. At the same time, the preferred speed is determined for the agent, which reflects the individual characteristics of the simulated driver. The choice of the occupied lane is influenced by two main factors:

1. the ability to move along the strip at the speed closest to the preferred speed of the agent;
2. The ability to make a necessary maneuver (specified permitted directions of traffic along the lanes) when leaves the road section (Frag, Lyons, 2012).

When driving on a strip without rebuilding the main decision taken by the agent-participant of the traffic is the choice of acceleration. The main purpose of changing the acceleration is to maintain a safe distance to the ahead agent "while maintaining the speed closest to the preferred one.

This chapter presents an overview of the traffic conditions in Beirut and how the population of Beirut is more inclined towards private transportation than public transport. The chapter also gives a view on the economic factors in transportation, gives approaches to transportation behavior and what role does habits and rules play in changing the mode of transportation. Later in the chapter are aims of the research and how the forthcoming chapters are aligned to support the research. The coming chapter will give a detail on the brief researches done in the area and later we will see how our study and model will be utilized in case of Beirut.



# CHAPTER TWO

## Existing Models for Mobility simulations



## **CHAPTER TWO: EXISTING MODELS FOR MOBILITY SIMULATIONS**

In order to create a harmony between different chapters for the reader, the researcher will be giving a brief recap of the last chapter. The previous chapter outlined different theories and mentioned the role of habits in the decision a person makes in choosing a mode of transportation. It is necessary at this stage to make a reflection on previous researches done in the same area. Therefore, this chapter will mainly focus on shedding light on researches and thus will make a connection with our research.

### **2.1 CONSIDERATION OF ECONOMIC AND SOCIAL BEHAVIOR FACTORS IN THE CHOICE OF MODES OF TRANSPORT OF ROLLING STOCK**

The choice of mode of transport for passenger transportation is associated with other determining factors. Passenger transport customers are mainly individual users whose requirements vary significantly depending on the solvency, psycho type, life priorities and are related to the purpose of the trip, its duration, the cost of travel, the convenience of the timetable, the quality of service before, during and after the trip, accessibility type of transport, development of the transport network and other factors (Innocenti, Lattarulo, Pazienza, 2013). The main criteria for choosing a mode of transport for passenger transportation are: savings of client funds, speed and comfort of movement, time saving, rational use of leisure time of the population, which determines the importance of passenger traffic as socially significant for the state and its economy. When choosing the method of delivery, the passenger is guided by his own assessment of the quality of transport services, comparing the convenience of the timetable and time for traveling, cost, comfort and other factors - benefits, discounts, advertising, a range of services for different modes of transport (Innocenti, Lattarulo, Pazienza, 2013).

All factors influencing the choice of mode of transport are classified into the following groups: technical and economic; sanitary and hygienic; architectural and planning; local conditions. If the first group has quantitative indicators, then the last three groups of such indicators do not have and the assessment for them can be subjective. Therefore, in the calculations use the technical and economic indicators, determined by comparing different modes of transport (Efthymiou, Antoniou, Waddell, 2013).

Technical and economic indicators compare types of transport and types of rolling stock:

1. When selecting modes of transport under operating conditions in directions where the existing mode of transport or the type of rolling stock does not provide transportation;
2. In the design of transport systems, as well as in their development in Beirut where transport is available;
3. In determining the areas of rational use of types and modes of transport and their quantitative ratio

When choosing the mode of transport under operational conditions, the most economical modes of transport and the capacity of rolling stock for the cost of transportation are determined. For comparison, it is necessary to know the following indicators: the actual volume of passenger traffic; operating speed; allowed limits of intervals of motion; the capacity of vehicles available in the transport enterprise (Efthymiou, Antoniou, Waddell, 2013). This is similar to the question of choosing modes of transport on a separate direction between points in the development of the transport system of Beirut. However, when comparing it is important to take into account the costs of investment in the construction and purchase of vehicles.

The definition of the areas of rational use of modes of transport and types of rolling stock should not be identified with the choice of mode of transport, since in the latter case all factors are taken into account, and in the latter, their limited number (Górecka, 2016). In determining the areas of rational use of modes of transport and types of rolling stock, the limits in the intervals of which this type of transport and the type of rolling stock will have the best economic indicators.

To organize the traffic along the route, it is necessary to choose a rational rolling stock. The essence of this issue is the assignment to the route of such a number of vehicles of a certain passenger capacity, which provides a minimum of costs for the carrier provided that the passenger flow is developed in compliance with the regulatory requirements for the quality of transport services (Ding, Lin, Liu, 2014). At the same time, the type of vehicles should be selected taking into account future transportation needs in order to form a rational structure of the company's park for the future.

The choice of rolling stock is connected, first of all, with the definition of its nominal capacity. Since it is this characteristic of a passenger vehicle that affects the main indicators of its performance: turnaround time, transportation costs, etc.

The capacity of the rolling stock is determined by its design features. When choosing the capacity of the rolling stock, the following factors are considered:

1. The capacity of passenger traffic in one direction on the most loaded section.
2. The uneven distribution of passenger traffic over the hours of the day and sections of the route.
3. Appropriate interval of vehicles on the hour of the day (Whalen, Páez, Carrasco, 2013).
4. Road conditions for the movement of rolling stock and the carrying capacity of streets (in some streets the movement of rolling stock of large capacity can be limited in size).
5. Cost of transportation.

The rolling stock according to capacity should correspond to the maximum power and character of passenger traffic (Crockett, Hare, et al., 2016).

The capacity of passenger traffic is established during the survey of passenger traffic. Since the passenger traffic over the hours of the day can significantly fluctuate (peak hours, peak periods, etc.), then for the characteristic periods of the day, a rolling stock of different capacities can be used (Shepherd, Bonsall, Harrison, 2012). However, in practice, not all carriers have the ability within a day to replace the rolling stock from a smaller capacity to a larger one and vice versa. Therefore, for work on the route, choose one type of rolling stock, the capacity of which is established based on the data on the hourly capacity of passenger traffic on the most loaded part of the route for the peak hours or its capacity per day along the route as a whole.

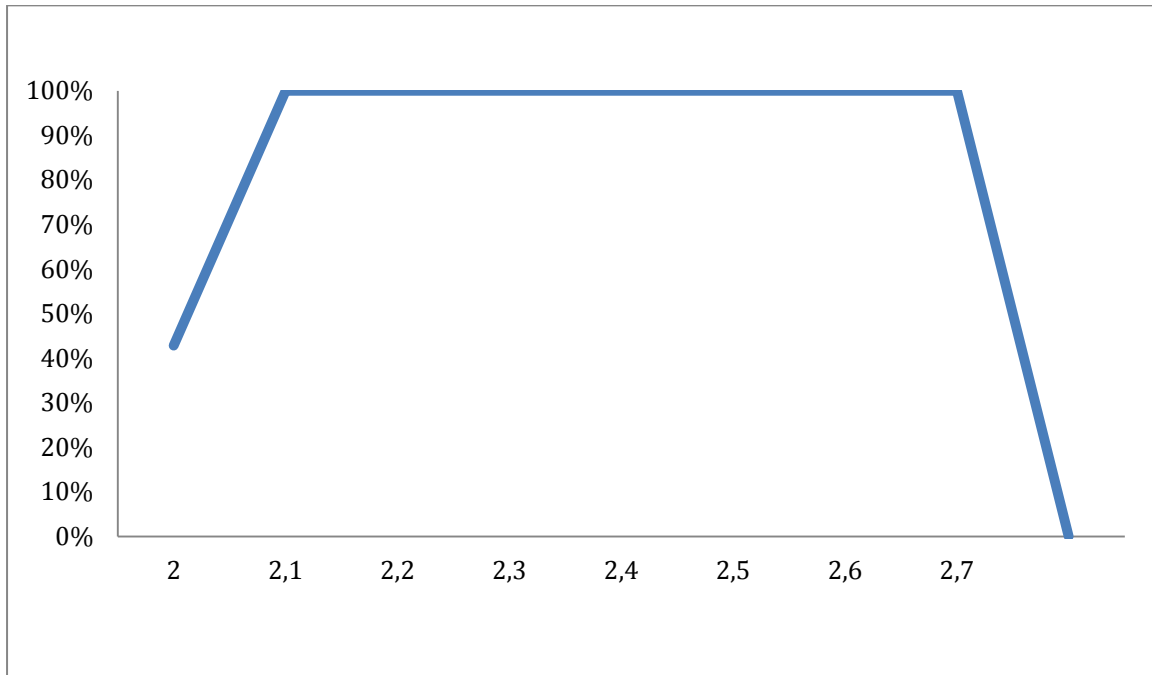
The expedient interval along the route is an important criterion for choosing the rational capacity of the rolling stock. The value of the interval of motion is set taking into account various restrictions (Lewandowski, et al., 2015). The traffic interval should not be too long (in Beirut it is not recommended to set the intervals of traffic for more than 20 minutes), because with a rare message on the route passengers have to spend a lot of time waiting for vehicles. The prospect of prolonged waiting at a stopping point forces many passengers to choose other ways of traveling: to use adjacent routes in a passing direction, making transplants; resort to taxi services. Therefore, long intervals of traffic, firstly, create inconvenience to passengers, and secondly, they can lead to their loss and decrease in revenue from transportation on a particular route. At the same time, it is not advantageous for the carrier to install very small intervals of motion, because setting a small value of the interval of traffic will require a large number of machines, which, as a consequence, will lead to an increase in the costs of the enterprise associated with servicing the route (Mitra, 2013). Thus, the specific value of the passenger traffic and the given traffic interval, which meets the conditions of passenger transportation along the route, determine the nominal capacity of the rolling stock (Gao, Koo, 2014).

The rolling stock of large capacity cannot be used on routes with low passenger traffic. Since in this case the level of utilization of the capacity of the vehicle will be low, which will lead to an increase in the cost of transportation? To increase the level of utilization of the rolling stock, it will be necessary to increase the range of its movement, so that more passengers accumulate at the stopping points, but this circumstance, as noted above, will cause inconvenience to passengers and may lead to a decrease in revenues (Titheridge, 2017).

It is also not efficient to operate small-capacity vehicles on routes with powerful passenger traffic. Since in this case for transportation of all passengers vehicles will need to walk more often, and the interval of their movement will decrease, which, according to the demand of a large number of machines for work on the route. Even if the carrier has a sufficient number of rolling stock, a large number of them can lead to an increase in transportation costs (fuel and lubricants, wages to drivers, etc.) (Chorus & Kroesen, 2014). Therefore, when choosing the capacity of the rolling stock, they are guided not only by the establishment of an acceptable interval for passengers, but also by the costs of transporting passengers along the route, which in turn also depend on the capacity. The main relevant costs, the amount of which is directly related to the selected capacity of the rolling stock, include operating costs (expenses for fuel and lubricants, tires, etc.) and wages to drivers. Consider how the corresponding costs depend on the capacity of the rolling stock operated along the route. The



operating costs (K) per mileage along the route for each unit of the rolling stock increase almost in proportion to the increase in its capacity (Figure 1).



**Fig. 1. Dependence of operating costs on the capacity of rolling stock**

After determining the capacity and the required number of rolling stock, it is necessary to make its distribution for the periods of the day, taking into account the fluctuations in passenger traffic for the organization of the work of drivers for shifts (Madhuwanthi, et al., 2016).

## *2.2 PRINCIPLES OF CHOOSING MODES OF TRANSPORT*

### *2.2.1 INTERACTION OF VARIOUS TYPES OF TRANSPORT*

The task of choosing a mode of transport is fundamental in transport logistics, and it is solved in close relationship with other tasks. In this case, it is necessary to distinguish between the conditions for choosing the mode of transport: current and prospective. In the current planning, consumers of transport services make a choice from existing transport modes in the country or region. In the second - taking into account their possible development and creation of new ways of moving goods and people. The basis for choosing the type of transport optimal for a particular transport is information about the characteristics of different modes of transport, their capabilities and disadvantages.

## 2.2.2 THE BASIC PRINCIPLES OF CHOOSING MODES OF TRANSPORT

*1st principle* - the choice of mode of transport is carried out by consumers of transport services, in contrast to the previously existing in the field of transport of goods of centralized distribution (Zhao, 2015). This means that transport workers must learn to sell transport services in the transport market.

*2nd principles* - the main criterion for choosing the mode of transport are the costs of consumers for transportation services. Additional criteria may be minimum delivery time, safety, reliability, safety, environmental friendliness and other indicators.

*3rd principle is to* ensure comparability of cost and natural indicators of comparable transport options. All cost components are compared on the entire route of the cargo from the sender's warehouse to the consignee's warehouse. Calculation of transportation options must be carried out for the same volume of traffic between the same moving points (Kim, & Park, 2015).

*4th principle* - Ensuring reliable and sufficient information of consumers of transport services, in particular through advertising, on the quality and cost of transport services for customer service. Objective information allows consumers to make comparative calculations to optimize their transportation costs, rationalize transportation, identify more profitable markets for their products, manage the transport component in the price of the goods (Kim, & Park, 2015).

The above principles predetermine the methods of choice of transport, which differ among themselves in the ways of accounting for certain indicators. Because it is very difficult to take into account the many economic and social behavior factors influencing the choice of the mode of transport at the same time, in practice the generalized cost indicators are first calculated, and then the natural and technical-operational values are compared.

## 2.3 FACTORS INFLUENCING THE CHOICE OF MODEL OF TRANSPORT

There are six main economic and social behavior factors influencing the choice of mode of transport:

- ✓ reliability of the delivery schedule;
- ✓ Delivery time;
- ✓ cost of transportation;
- ✓ Frequency of departures;
- ✓ ability to transport different loads;
- ✓ the ability to deliver cargo anywhere in the territory.

Table 1 provide an assessment of various types of public transport for each of these factor:

Table 2.1 - Assessment of various modes of transport (The table is a sample and thus has been left empty)

Type of transport	Factors influencing the choice of mode

	of transport				
Delivery time	Frequency of departures	Reliability of the delivery schedule	Ability to transport different cargoes	Ability to deliver cargo anywhere in the territory	The cost of transportation
Railway					
Water					
Automotive					
Pipeline					
Air					

These data can serve only for an approximate assessment of the degree to which a particular mode of transport meets the conditions of a particular transport. The correctness of the choice made should be confirmed by technical and economic calculations based on an analysis of all costs associated with transportation by various modes of transport.

The choice of the way of transportation of goods is one of the important tasks solved by cargo owners. At the same time, alternative modes of transportation have three independent, but interrelated directions: 1) the choice of the type or modes of transport; 2) the choice of certain vehicles of a particular mode of transport; 3) the choice of the carrier delivering the goods (Kim, & Park, 2015). In general, a number of objective and subjective conditions affect the choice of the way of transportation of goods, which can be reduced to several basic positions.

Table 2.2 - Basic conditions for choosing the transportation method

Criteria for selection	Content
Opportunity	Current - existing modes of transport in the given territorial formation; perspective - the future development of the transport network in this territorial formation.
Options	The choice of transportation is limited for various reasons. The choice of transportation is almost unlimited
Principles	Comparability of indicators for different modes of transport. Degree of information service of transport services
Methods	Full accounting of the indicators compared. Limited account of the indicators compared

Indicators	Quantitative indicators by mode of transport. Qualitative indicators by mode of transport.
Factors	Ownership of vehicles. The accepted system of cargo insurance. Banking options.
Criteria	Economic (cost) indicators. Natural indicators. Technical and operational characteristics.

1) **The choice of the** method of delivery of goods is determined by modes of transport existing in a particular territorial formation, which consumers of transport services have the opportunity to choose. Accordingly, the cost of moving cargo in the current opportunity when choosing transport channels for goods movement is accounted for in the tariffs for transportation and other services established in this territorial formation, including service ones. With the perspective possibility of choosing the mode of transportation - the future development of the transport network in a given territorial formation - the resulted operational and construction costs are taken into account.

2) The **options for limiting the choice of the** mode of transportation depend on the geographical and production characteristics of certain territorial entities, for example, mass delivery of goods to remote areas is possible, mainly by river transport only during the navigation period (Chee & Fernandez, 2013). In addition, the delivery of coal to thermal power plants or iron ore raw materials to metallurgical plants is carried out, as a rule, by railways using access railroads. Therefore, in the above variants, the choice of the mode of transportation of goods is substantially limited. As for small-lot shipments delivered to consumers in territorial formations with a developed network of railways, the choice of modes of transport is very wide - rail, road, inland waterway, air transport.

3) When considering the cost and natural indicators of the compared options, the cost elements are compared on the entire path of the cargo movement - from the shipper's warehouse to the warehouse of the consignee, including possible intermediate cargo transshipments. At the same time, the differences in the structure of costs by mode of transport and the operations of the transportation process are given in a comparable form, and the transportation options are calculated for the same volume of goods between the same transfer points. The principle of providing reliable and sufficient information to consumers of transport services is an important position when deciding on the choice of mode of transportation (Obokata, et al., 2014). Objective information about transport services allows consumers to conduct comparative analysis and optimization of costs for various transport options.

4) The above principles largely determine the **methods of transport choice**, which differ in the ways or completeness of accounting for one or other of the compared indicators - a complete accounting of virtually all the indicators compared for different modes of transport or a limited consideration of the generalized compared indicators by mode of transportation (Macal & North, 2010).

5) **The indicators** for selecting the type of transport involved in the transport process are divided into quantitative and qualitative, which, in turn, are classified as common for all modes of transport and private, inherent to certain modes of transport.

6) **Factors of choosing the mode of transportation** include in their composition: the forms of ownership of transport enterprises and vehicles - carriers; accepted systems of cargo insurance - cargo insurance in case of its physical loss or damage, liability insurance.

7) **Criteria for choosing the method of cargo transportation are classified into:**

- **economic indicators**, including tariffs and prices for transportation and other transport services, the cost of transportation, profit, profitability, specific capital investments, capital intensity, the cost of cargo mass in transit, interest rates on loans, taxes, excises, customs fees;

- **Natural indicators** - the volume and range of transport, the amount of demand for transport services, freight turnover, freight traffic, the need for labor, labor productivity, the need for fuel and energy resources and materials;

- **technical and operational** characteristics of modes of transport - speed of rolling stock, the range of transportation, the carrying capacity of a vehicle, the carrying capacity of transport, the productive power of vehicles (Holmgren, et al., 2012).

**The choice of the type or types of transport is carried out according to the following criteria:**

- ✓ economy of cargo transportation;
- ✓ the ability to deliver goods to any point of territorial formation;
- ✓ location of the network of communication routes;
- ✓ Seasonality and rhythm of the work of transport in various meteorological conditions;
- ✓ carrying capacity of transport;
- ✓ distance of transportation;
- ✓ Risks arising during the transportation of goods

The choice of the type or a mode of transport, vehicles and the carrier is carried out in two main directions - the costs of transporting goods and the time of their delivery to the consumer, which, if possible, should be minimized, therefore, two corresponding tasks must be solved. The first task is to minimize transportation costs (Ortuzar, Willumsen, 2011).

The second task is to minimize the time for the end of all traffic. The simplest transportation scheme is the use of road transport, in which the delivery of goods is carried out, as a rule, directly from the cargo owner's warehouse to the consignee's warehouse without transshipment and railway transport in the presence of access roads from the consignor and the consignee. When choosing the option between road and rail, in this case, the limiting distances are used when deciding on the choice of a more rational option (Ben, Huang, Zhuang, Yan, 2013).

More complex are the transportation schemes for the railway version and especially for the mixed version. In mixed rail and road transport there are several options, namely: "car - railroad - car", "railroad access roads - railroad - car" and others. Naturally, with these options, additional reloading operations are assumed, and therefore additional costs for their implementation. Thus, the scheme of transportation "car - access railroad tracks - railway - access railroad tracks - car" involves six cargo operations, including four reloading operations (Crooks & Heppenstall, 2012).

In mixed railway and water communications there are also a number of transportation schemes, namely: "railroad - water" and "water - railway" with one cargo transshipment; "water - railroad - water" and "railroad - water - railroad" with two trans-shipment. At the same time, calculations show that multimodal transportation with several trans-shipment costs is higher than the delivery of goods to direct messages by one mode of transport. However, in practice, the organization of transportation of goods under the scheme of direct communication cannot always be carried out.

The ability to deliver goods to any point of territorial formation for each mode of transport is limited: for railway transport - by a network of railways; for road transport - a network of highways; for inland waterway transport - by the availability of navigable rivers; for air transport - the presence of airfields (Joo, et al., 2013). Consequently, the choice of the mode of transport according to this criterion, as a rule, consists in the search for the most optimal variant of the mixed transportation of goods.

#### *2.4 THE ENVIRONMENT OF SIMULATION OF TRANSPORT SYSTEMS*

Low-level agent modeling of traffic flows is an effective means of analyzing transport systems. Existing tools are too complex to be used by transport engineers or do not provide the necessary expansion capabilities. The developed environment is designed for two types of use: (1) transport engineers create models of systems and experiment with them; (2) simulation programmers expand the environment by adding new elements. The graphic designer simplifies the modeling process. The environment is based on the behavior model of the participant in the movement. The increasing traffic flows in Beirut dictate the need for reconstruction of existing ones and creation of new transport nodes (Crooks & Castle, 2012). Low-level simulation is an effective way of analyzing the throughput and other characteristics of small and medium transport systems. Currently, there are several tools for low-level modeling of transport systems. All considered systems, except Transport Library AnyLogic 5, are foreign developments and have a high cost, often unacceptable for domestic design organizations and municipalities. Modeling in many environments (VISSIM, Transmodeler) provides a rich set of capabilities, but it is often unreasonably complex and inaccessible to specialists in the field of knowledge, since it implies a profound knowledge of simulation technologies. In Transport Library AnyLogic 5 it is necessary to specify in detail the possible trajectories of traffic of cars, which makes it impossible, for example, to adequately simulate the rebuilding of cars when driving on a multi-lane road segment. Some (SIDRA Intersection) tools allow you to model only certain types of transport infrastructure objects (Grether, Fürbas, Nagel, 2013).

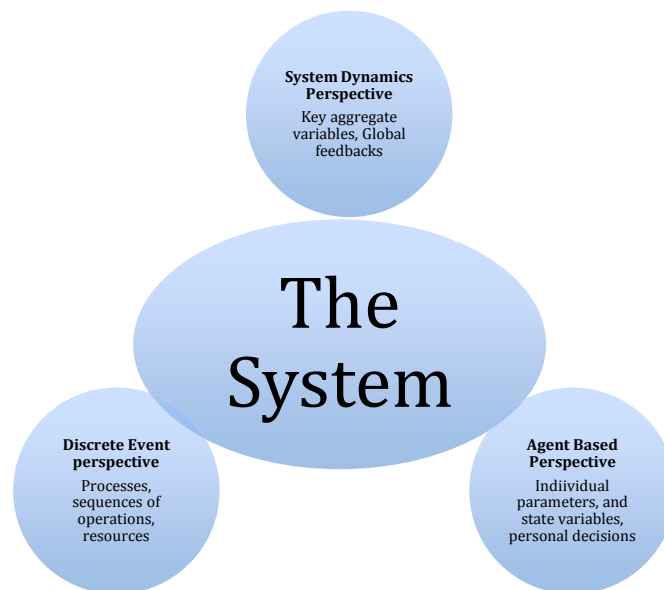
In these conditions, it seems expedient to create a new medium with the following properties:

- ✓ Simplicity of creation of models, orientation to experts of a subject domain, instead of on engineers-imitations;

- ✓ visualization of modeling, maximum visual similarity of the model and the modeled system;
- ✓ availability of convenient means of calibration of models, providing the possibility of increasing the adequacy of modeling;
- ✓ extensibility of models, enabling software engineers to enrich a set of model development tools.

Medium of low-level modeling of transport systems was decided to be created on the AnyLogic 6 platform, adopting the agent approach as the basis (Ingvaldsen, Özgöbek, Gulla, 2015). The rich visualization capabilities of AnyLogic 6 provide visibility both at the stage of model creation and during experiments. The general structure of the transport system-modeling environment is shown in Fig. 2.

Medium-scale modeling of transport systems (MMTS) consists of two subsystems - a model designer and an executing module. Model developers have the ability to create models in visual mode and save them to XML files. The experiments are carried out with the help of the executing module, which displays animation in the course of modeling. The results of the experiments can be displayed in databases or in Microsoft Excel files. The programmer-simulator has the ability to supplement the functionality of the environment by developing the necessary components in the form of AnyLogic plug-in libraries.



(Madhuwanthi, et al., 2016)

**Fig. 2.1 General structure of transport systems modeling environment**

**At the heart of the developed environment lies the algorithm of behavior of the agent - the participant of traffic. A three-level model of the behavior of the participant in the motion, shown in Fig.**

Three Revolutions in Urban Transportation		
Business-as-Usual Scenario  20 <sup>th</sup> Century Technology  Through 2050, we continue to use vehicles with internal combustion engines at an increased rate, and use transit and shared vehicles at the current rate, as population and income grow over time.	2 Revolutions (2R) Scenario  Electrification + Automation  We embrace more technology. Electric vehicles become common by 2030, and automated electric vehicles become dominant by 2040. However, we continue our current embrace of single-occupancy vehicles with even more car travel than the BAU.	3 Revolutions (3R) Scenario  Electrification+ Automation+ Sharing  We take the embrace of technology in the 2R scenario and then maximize the use of shared vehicle trips. By 2030, there is widespread ride sharing, increased transit performance-with on-demand availability-and strengthened infrastructure for walking and cycling, allowing maximum energy efficiency.

(Crockett, Hare, et al., 2016)

**Table 2.3 Structure of the participant's behavior model**

The upper, strategic, level of the model reflects the driver's choice of a sequence of road sections, intersections and road crossings. The driver's response to the surrounding traffic situation is simulated at the tactical and operational levels (McKerlich, Ives, McGreal, 2013). At the tactical level, the vehicle's trajectory is determined, its priority in the current situation and the preferred speed of the vehicle. At the same time, the driver's behavior largely depends on the type of transport infrastructure object on which the traffic is carried out. Known algorithms for succession and change of bands, which have been thoroughly investigated, for example, in, are also implemented at the tactical level. The operational level of the participant's behavior model is responsible for choosing the acceleration. Agents tend to move along their trajectory, giving way to more priority agents, avoiding collisions with the agents ahead and keeping to the speed, as close as possible to the preferred one.

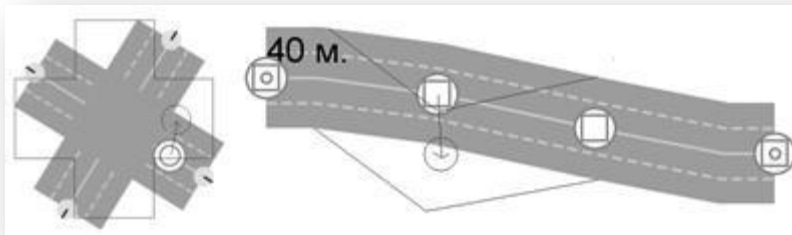
The structure of the simulated transport system is defined using the developed language for describing transport systems (Ghorbani, et al., 2014). A language is a collection of classes of elements  $C = \{C_1, \dots, C_N\}$  and rules for composing elements  $R = \{R_1, \dots, R_M\}$ . Two types of classes of elements are distinguished: basic (corresponding to real objects of the transport infrastructure) and auxiliary (serving to specify the model parameters). An example of a basic class of elements are the "intersection", "straight road", "parking" classes, etc. An auxiliary class of elements is the class "boundary of the simulated section", which allows to specify the traffic flow intensity at the entrance to the simulated transport system. To each class  $C_i$  there corresponds a set  $P_i$  of  $K_i$  properties  $P_i = \{P_{i1}, P_{iK_i}\}$ . The composition rule  $R_j$  of the elements of the classes  $C_p$  and  $C_q$  is a matrix of the form (1) in which the elements of the form  $R_{jxy}$  take on the values "true" if for the composition of the elements of the classes  $C_p$  and  $C_q$  the values of the corresponding properties of  $P_{px}$  and  $P_{qy}$ , "false" - otherwise.



$$R_j = \begin{matrix} R_{11}^j & \dots & R_{1Ke}^j \\ R_{Ke1}^j & \dots & R_{KeKe}^j \end{matrix} \quad (1)$$

To construct constructions of the language for describing transport systems, a graphic editor has been created, to each structural element of which there corresponds an element of the created language. The editor supports standard methods of user interaction with graphical environments, the following which allows to increase the intuitive development of models of transport systems. In addition, the created editor has a number of features that make it easy to create models:

- automatic setting of object parameters at their composition saves the user from having to manually configure the connected elements;
- Checking the syntactical correctness of structures and indicating places of violation of the syntax makes it easy to detect errors;
- wide use of service markers to change the properties of elements in the mode of graphic editing (Fig. 4). The service token is a portion of the screen that allows you to change some property of the structural element through the manipulation of the mouse (Macal, 2016).



(Lewandowski, et al., 2015)

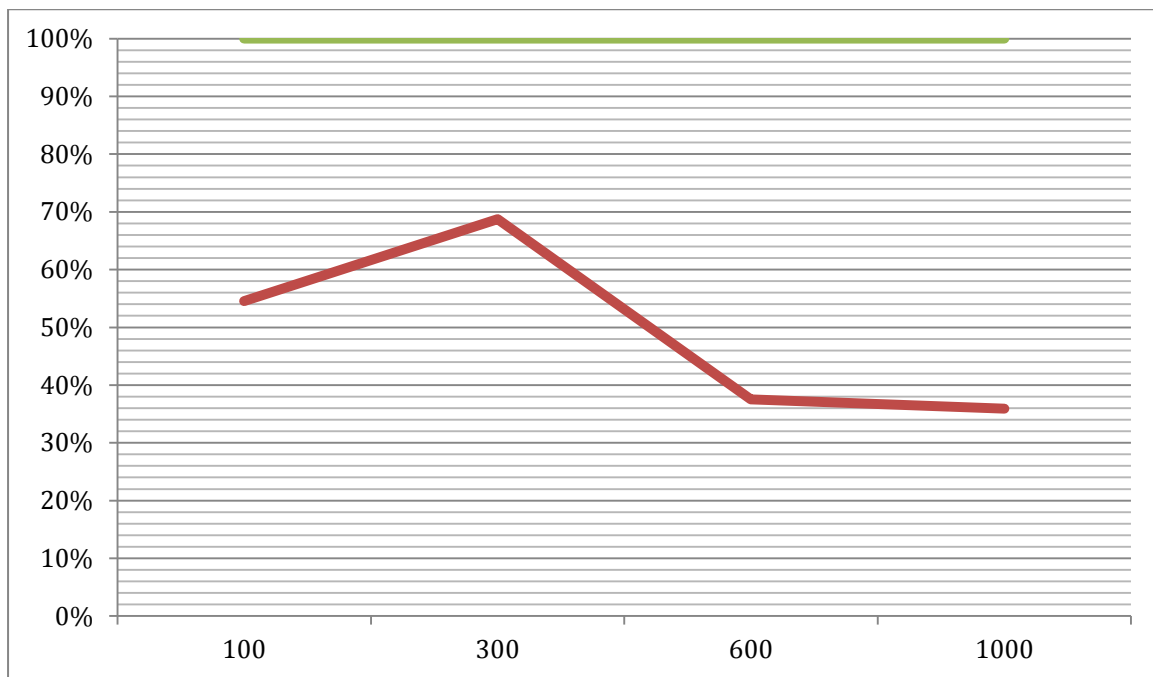
Fig. 2.2 Use of service markers for editing the shape and position of structural elements

An important factor in the usefulness of the simulation environment is its performance in experimenting with models of large systems. Agents in the proposed model make decisions on each of the levels with different intensity (Ascensão, et al., 2013). The complexity of decision-making algorithms is presented in the table.

The complexity of decision-making algorithms in the participant model

Level of decision making	Intensity of decision-making	Complexity of decision algorithms
strategic	from 1 to several times during the life of the agent	$O(n^2 \cdot \ln(n))$ , where $n$ is the number of vertices in the graph representing the road map of the simulated section.
tactical	from 1 to 15 times per minute model time	$O(n \cdot \ln(n))$ , where $n$ is the number of agents on the same road segment as the agent in question.
operational	from 1 to 5 times per second of the model time	$O(n^2)$ , where $n$ is the number of agents in the circle of attention of the agent in question.

Fig. 2.3 shows the ratio of the simulation speed to the number of agents in the modeling of the average *transport system* with 10 intersections and 18 road segments. It can be seen that the environment is capable of providing real-time simulation mode at 715 agents.



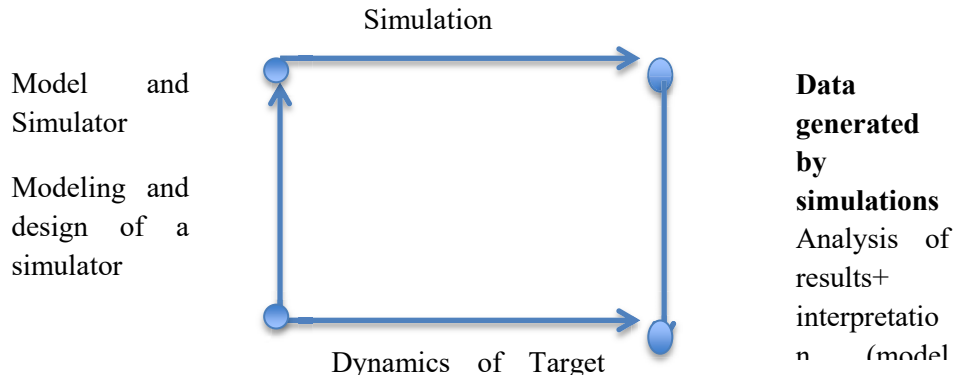
(Titheridge, 2017)

**Fig. 2.3 The ratio of the speed of modeling and the number of agents**

The result of the study was the environment of agent simulation of transport systems on the AnyLogic platform. A model of the behavior of a road user that reflects many aspects of the behavior of drivers on the roads is proposed. Traditional algorithms for following and changing lanes are adapted for traffic cases in different parts of the road infrastructure. The model is the basis for the developed environment. The structure of the modeling environment provides its extensibility by adding new components (Hamill, Gilbert, 2015). The developed graphic editor of transport system models is a convenient and intuitive tool for describing the simulated road and transport infrastructure.

## ***2.5 AGENT BASED MODELING AND SIMULATION: PROSPECTS IN THE FIELD OF INFORMATION TECHNOLOGY***

The concept of computer simulation involves the use of a computer model to study the behavior of complex systems (for example, biological and social) that provide the ability to make their own decisions. It also allows you to evaluate concepts and projects without implementing them (for example, architectural projects and road systems). The use of such a "synthesized environment" is often necessary, since such a system cannot be explored in the real world for ethical reasons (for example, such an experiment is unsafe for people) and practical (too much cost of experimentation, too slow speed of system evolution). In Fig. 2.4 depicts a basic outline based on the studies of Gilbert, Troitzsch (2005) and Edmonds (2001), which describes the role of MIS (Management Information System) as a tool for predicting or explaining.



(Madhuwanthi, et al., 2016)

***Fig. 2.4 Basic scheme for describing the role of MI as a prognostic or explanatory tool***

Some situations and subsystems can be characterized by the interaction of many autonomous entities whose behavior (actions and interactions) determine the development of the entire system. ABM (Agent Based Modelling) is especially suitable for such situations and has the opportunity to study and analyze such phenomena as decentralized decision-making, local-global interactions, self-organization, development and effects of heterogeneity in artificial systems. Interest in this approach

has been growing steadily lately - this can be judged by the appearance of many events dedicated to the ABM (Agent Based Modelling). Models based on autonomous agents have been successfully used to simulate complex systems in various areas, from logistic optimization and biological systems to simulation of transport systems, pedestrian systems and urban planning. ABMs have also been successfully introduced into the social sciences and the economy (Hamill, Gilbert, 2015).

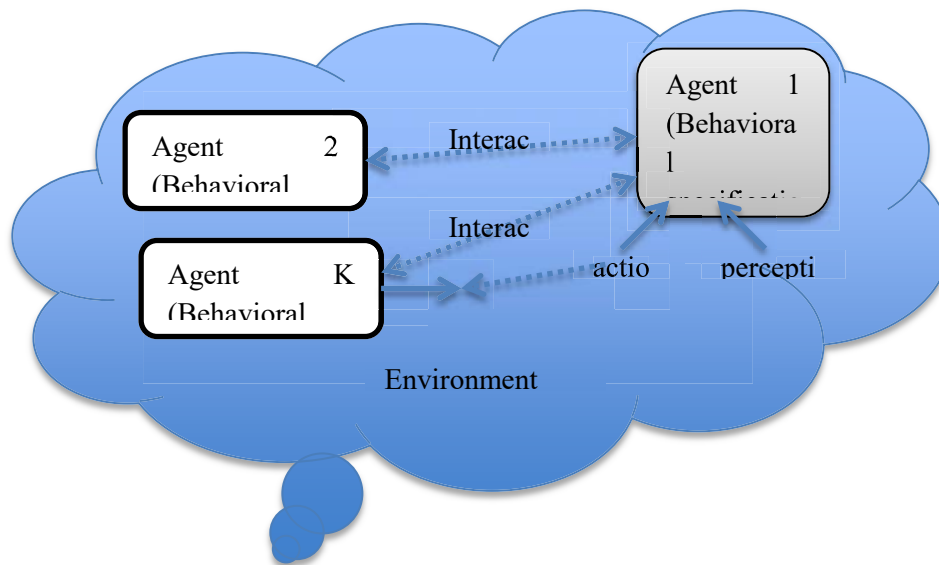
Extreme heterogeneity (especially in ABM) in artificial environments is often associated with the fact that impacts can occur in different research fields. For example, in transport and pedestrian dynamics, a large number of models depend on physics, and therefore in related models pedestrians are viewed as agents influenced by forces generated by the environment or other agents. Another approach to pedestrian systems is based on experiments with cellular automata (CA) models of pedestrians, which demonstrate a more distinct division between the environment and the objects that live, operate and interact in it. This area of research allows us to explain models with multi-agent systems (MAS) successfully explained and implemented in the concept of reactive robotics and control systems. The models and simulations used in the social sciences and the economy are based on different theories of human behavior. This allows you to get new knowledge about this behavior, as well as build and verify new theories.

All the above ABM, like many others, has the general idea of a simulated system: an analytic unit is considered as an individual agent acting and interacting with other objects in the general environment. System dynamics is most fully described not by any general function, but rather by the actions and interactions of individuals (Ronald, Thompson, Winter, 2015). It is important to understand that in spite of the fact that agents play a key role in this approach, in most cases the environment in which they are represented plays a special role, since:

- It strongly influences the behavior of simulated objects, determining the knowledge and actions of agents;
- the goal of MI is to study some behaviors at an aggregated level (for example, the density of certain types of agents in the environment, the movement of mobile agents, the generation of groups of agents) that can only be studied within the environment.

In addition to such common elements, approaches to ABM often differ greatly in how to describe both behavior and agent properties v. The same can be said about their environment.

However, the purpose of this article is to describe an abstract and model that can be used to analyze, describe and interpret various Agent Based Modeling and Simulations, including those already created. Such a model is shown in Fig. 2.5:



(Kim, & Park, 2015)

**Fig. 2.5 Typical Agent Based Modeling and Simulation.**

The main elements of the above model:

- ✓ agents covering all possible characteristics of heterogeneous behavior;
- ✓ their environment, which determines the representations and actions of agents;
- ✓ mechanisms of interaction between agents, including direct and indirect transmission of information between them. This possibility is realized by regulating the ability of one agent to learn about the behavior of the other.

Further, in the text, these elements are analyzed using the IT literature on ABM. Classifications and typologies are also introduced. After that, the article tells about various computer platforms that allow creating ABM. In conclusion, thoughts are given on the future prospects and ways of developing this multidisciplinary approach.

## 2.6 AGENT BASED MODELING AND SIMULATIONS

A model is an abstract and generalized simulation of an existing or perceived reality. Basically, models are developed to study or explain the studied, or predict future events. As stated above, the ABM is characterized by the existence of agents carrying out certain activities in the general environment. However, there is no unambiguous concept of this term even in the community of researchers in this field (Ronald, Thompson, Winter, 2015). The generally accepted Wooldridge definition is formulated as a set of object features that are sufficient for naming it as an agent. These features include:

- autonomy - the ability to function without human intervention and the ability to some extent control their condition;
- ability to social interaction - the possibility of interaction between agents using a specific language;
- reactivity - the ability to feel the environment in which the agent is located and react to its changes;
- Preventiveness is the ability of agents to act on their own initiative to achieve an internal goal.

The purpose of this chapter is to present some research results in the field of agent models and applied technologies in this field in order to compare the current state of research in the field of Agent Based Modeling with other transportation. (Watkins, et al., 2015).

As mentioned earlier, Agent Based Modeling and Simulations are models of complex systems, and in this approach it is assumed that simple and complex phenomena are the results of interaction of autonomous and independent objects (agents) that function within communities in accordance with various types of behavior. However, agents and ABM are not only considered modeling technology, but also as an approach that allows us to describe total systems formed from individual components and their behavior. The study of such evolving behaviors is characteristic of complex systems modeling, and for this purpose ABM is increasingly (Sarraf Shirazi, et al., 2014).

#### *2.6.1 CHARACTERISTIC FEATURES OF THE BEHAVIOR OF AGENTS*

According to Wooldridge, we can distinguish two features of the behavior of agents. First, you need to correctly determine the actions of agents. Actions are the basic elements of agent behavior: they can cause changes in the environment or in other agents included in the model (Harris, Pierpoint, 2012). Using the following methods, the following agent actions can be described:

- changing the global state of the system;
- local environment change;
- reaction to impacts;
- execution of computing processes within agents for processing received information and changing its state;
- physical displacement of the agent in the spatial structure of the medium.

Features of agent behavior also include mechanisms for efficiently selecting the actions to be performed depending on the agent's views and internal state. The notion of "architecture" denotes the model of the internal structure of the agent responsible for choosing the type of behavior. You can divide the architecture into thinking (cognitive) and reactive (reactive) (according to Genesereth, 1987 - hysterical and tropic) (Tyrinopoulos, Antoniou, 2013).

Reactive agents are simple (mostly with no memory) agents with an assigned position in the medium. Reactive agents act by catching "stimuli" coming from either other agents or from the environment; in general, the behavioral specification of this agent type is a series of rules of the "condition-action"

type with the addition of an action selection strategy that is executed whenever possible further actions are possible. In this case, the signal for the action is an initiating event coming from the environment. Reactive agents cannot be preventive.

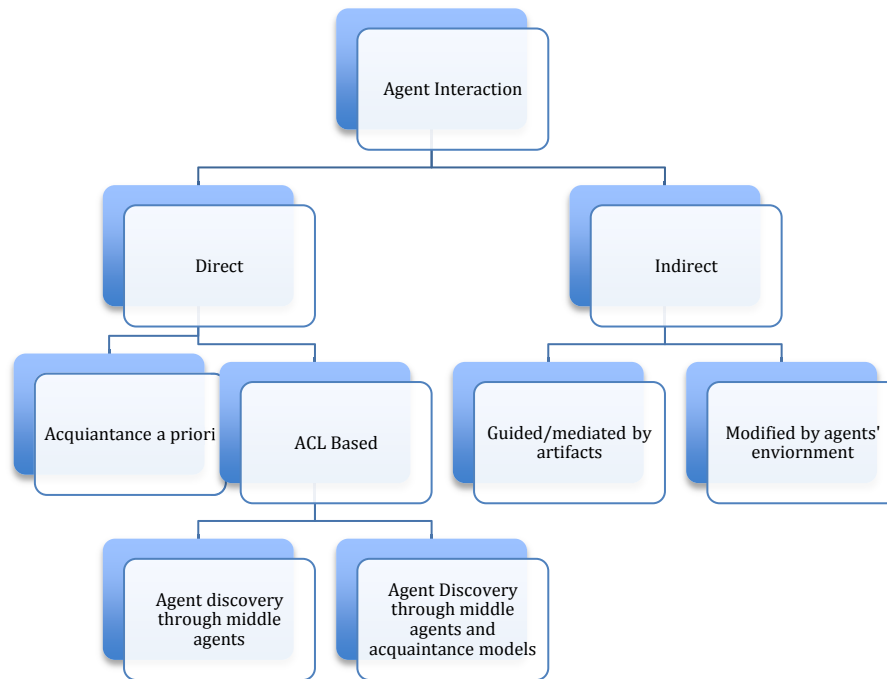
MAS can consist of cognitive agents (usually a relatively low number of reactive agents) having their own knowledge models that determine its behavior and its interactions with other agents and the environment. However, there are even MAS, consisting only of reactive agents. Such models are based on the idea that there is no need for the individual mind of agents to imitate complex behaviors. Another advantage of reactive MAS is its flexibility and adaptability. Finally, the system can also be represented by an inhomogeneous composition of reactive and cognitive agents (Kamruzzaman, et al., 2013).

In order to give an example according to the above classification, further ABMs based on the physical approach will be considered; The latter basically considers agents as units that are both subjects and the main driving force. In this case, the environment includes laws that regulate such impacts and elements of the system that are not agents (for example, reference frames that form attractive / repulsive forces). Such environments determine the dynamics as a whole, combining the effects that affect each agent and its associated elements, at discrete time intervals. In this case, the environment covers all the above-described dependencies, and the role of agents is minimized. The model so constructed basically reduces to an iteratively computable set of equations. In existing methods of building ABM agents generally have greater autonomy and control over their own actions in assessing impacts and making decisions based on behavioral features. The environment at the same time retains a very important role, since it supports the existence of agents and their effects, which arise in accordance with the current structure of the system and the location of agents within it (Chang, 2013). Socioeconomic MIs offer a large number of approaches that reproduce the observable system, but in general they have the same principle as ABM. For example, relations between agents arise as a result of a two-phase process in which agents choose a partner to interact with it based on an "alert", that is, through mutual information.

### *2.6.2 AGENT INTERACTIONS*

Interaction is a key element of the ABM. There are many definitions of the agent, and most of them highlight the possibility of objects interacting with each other and with the environment to solve their problems or achieve goals through coordination, cooperation and competition. Nevertheless, it is very important to correctly choose the assumptions made when developing or selecting an existing interactive model, since they have a great influence on the definition of the agents themselves (for example, decoding the language of the model, receiving signals). Thus, it is not surprising that much of the research in the field of agent modeling focuses on this aspect (Chang, 2013).

Below is a classification of the currently existing models of agent interaction (MAB) (see Figure 2.6), which systematizes perspectives and issues from the conceptual and technical point of view related to this area.



(Broberg, Sarjala, 2015)

**Fig. 2.6 Classification of models of agent interaction**

There are many aspects and options for MABs that describe this scheme.

The first aspect is related to whether the agents interact directly (for example, by means of messaging). In the case of direct interaction, the communication channel is either actual, or there are means of communication in the model that affect communication between agents. Despite the fact that models with direct interaction are used very often, they are not without many problems (Donald, Cooper & Conchie, 2014). For example, in order to communicate effectively, agents must "know" each other, that is, they need to assign unique names that will identify them throughout the system. In addition, agents must "be able" to discover the names of other agents in the system. When using models in which agents have a special language for communication ( ACL based in Fig. 8), the above problems are solved in such a way that such language gives agents a priori "acquaintances" with each other; the introduction of intermediary agents to provide information support and the development of more sophisticated models of "dating" allows you to solve issues related to the storage and presentation of information about such relationships, and also makes the architecture of the model more reliable and scalable.

Nevertheless, there are other models of agents 'interaction, they allow to create and operate tools that use means of communication for agents' interaction. Other models of indirect interaction are more focused on modeling the environment as a place where agents interact and determine their activities (Diodato, Ghezzi, Tiranti, 2014).

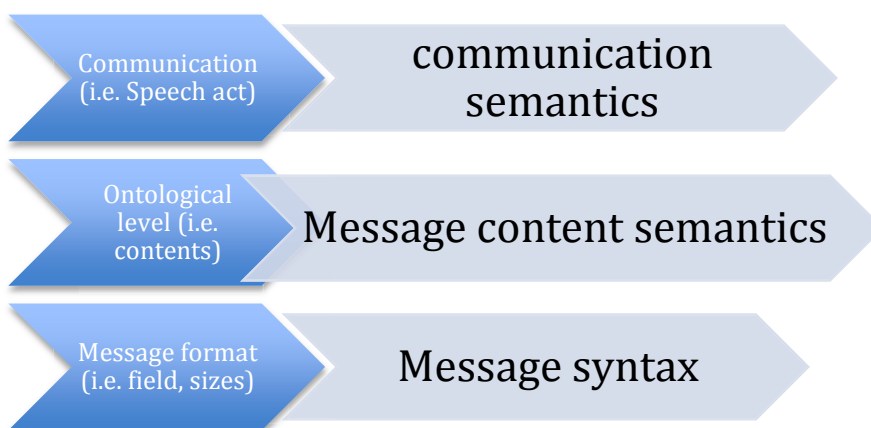


### 2.6.2.1 Models of direct interaction

The first and most frequently used form of the agent interaction model is the exchange of information between agents. This approach ignores communication channels that provide interoperability between agents, and does not even include it as an element of the abstract interaction model. Typically, these mechanisms provide a point-to-point messaging protocol that regulates messaging between agents. There are many methods for modeling communicative acts, but in general, such a protocol in most cases copes with its tasks. Although this approach has been well studied and can be effectively implemented (especially as it is mainly used in computer network protocols), direct interaction models need to develop specific architectural and conceptual solutions to issues related to the agent familiarity / learning algorithm and ontology.

Intuitively, the language of agent communication (ACL) provides them with a means of sharing information and knowledge (see Figure 9). This vague definition inherently includes part of the term "agent" itself, according to which the agent is an intellectual autonomous unit with certain social abilities. According to some approaches, it is this function that determines the essence of the agent. Leaving aside the definition and concept of the agent, the following explains what actually means the expression "social abilities" (Ingvaldsen, Özgöbek, Gulla, 2015). To explain these capabilities, it is necessary to briefly compare the similarities of ACL with those that are capable of circulating information between components using information channels (for example, inheritance systems) that enable the exchange of messages using a computer network (that is, at a lower level of communication). AS L differ from such systems by other objects of research and complex content. In particular, distributed computing protocols do not cope with:

- The autonomy of interacting components: the components of modern systems (even in the case when systems are quite complex and can have autonomy with respect to the performance of certain tasks), have a lower degree of autonomy than that inherent in agents;
- information transmitted in messages that does not require ontological at all (under the ontology is meant the formal representation of the set of concepts within the domain and the relationship between these concepts) of the approach, since the structures and categories are distributed among the system components.



(Ingvaldsen, Özgöbek, Gulla, 2015)

**Fig. 2.7 Layers and departments of ACL**

Regarding autonomy, while traditional software components basically perform the necessary actions as responses to external requests, agents can decide not to perform a task that is requested by another element of the system. In addition, agents are able to function continuously and prevent events in the future, which are impossible for normal software components (Whalen, Páez, Carrasco, 2013).

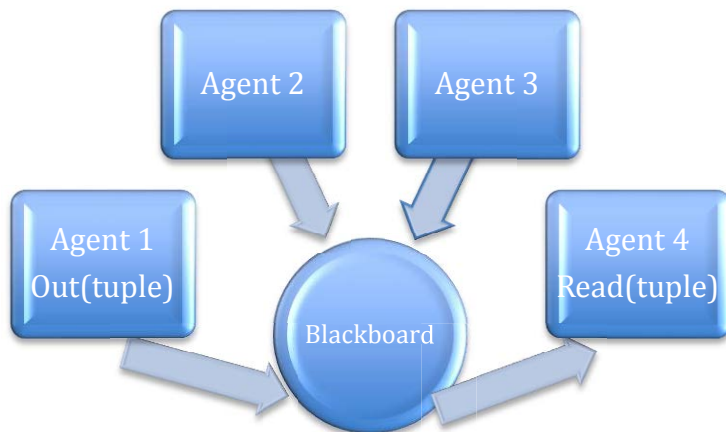
Regarding the second point, the components have certain interfaces that allow coordinating distributed structural data. The collected information and messages / requests / requests are conducted in a separate modeling language, which is nevertheless closely related to the model itself. To interact with agents, they need to have an explicit and comprehensive description of the subject area.

### 2.6.3 MODELS OF INDIRECT INTERACTION

Strictly speaking, communication between agents is usually indirect, even in direct interaction models. In fact, most of these approaches describe the communication infrastructure that provides a mechanism for transmitting messages "from one end to the other." Nevertheless, the use of the direct interaction model of agents raises a number of problems described above. Further in the text attention is paid to the description of intermediate structures that provide and regulate interactions between agents (McKerlich, Ives, McGreal, 2013). Such "communication abstractions" are the most attractive concepts in models.

Models of agent interactions, using indirect communication mechanisms, can be divided into artifact- mediating and spatially oriented. Artifact-mediated models allow creating artifacts that mimic specific objects of the agent environment for the purpose of communication between autonomous structures. Spatially oriented interaction models allow modeling situations where the spatial location of the agent environment is the key one and cannot be neglected.

Both approaches allow creating interaction mechanisms that are very different from simple information transfer "from object to object". In fact, the means of communication really create a context that affects communication between agents.



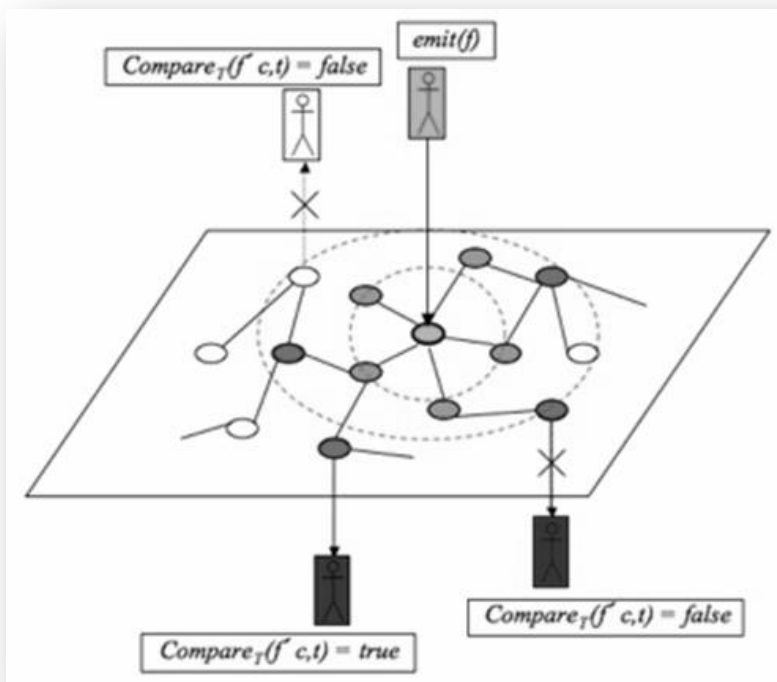
(Kamruzzaman, et al., 2015)

**Fig. 2.8 Diagram of the architecture of the "bulletin board" model, which includes two elements of the Linda coordination model, namely the output of the record on the board (the input operation) and the receipt of information by the agent through the bulletin board ( read operation).**

In actuality, a gathering of physical operators connect and appropriate assets not just through aggressive access to them (for instance, autos on avenues and intersection), yet additionally working together to achieve errands that cannot be performed alone because of absence of skills and capacities for instance, individuals who together bear an awesome duty). All the time, keeping in mind the end goal to have the capacity to control the connections related with this sort of assets, it is important to make certain antiques, for example, activity lights in the city or joined pens on substantial overwhelming boxes (Kamruzzaman, et al., 2015). In this way, some ways to deal with the specialist collaboration issue tend to model and utilize reflections that enable operators to coordinate through a typical asset, access to which is directed by precisely characterized rules. The design of the release board (see Figure 2.8) is one case of this kind of model. The notice board is a typical information stockroom that enables you to team up with program modules, conveying in a roundabout way and secretly. Specifically, the idea of the information recording space initially utilized as a part of the Linda show is a typical adjustment of the essential announcement board demonstrates.

Linda Coordination Language is the most widely used way to create a bulletin board. It is based on the concept of data storage space, which combines a bulletin board that allows agents to share and share information (records) using data-matching mechanisms integrated with the board (for example, comparison and unification). Linda It also uses a simple language that defines the mechanisms for accessing this space.

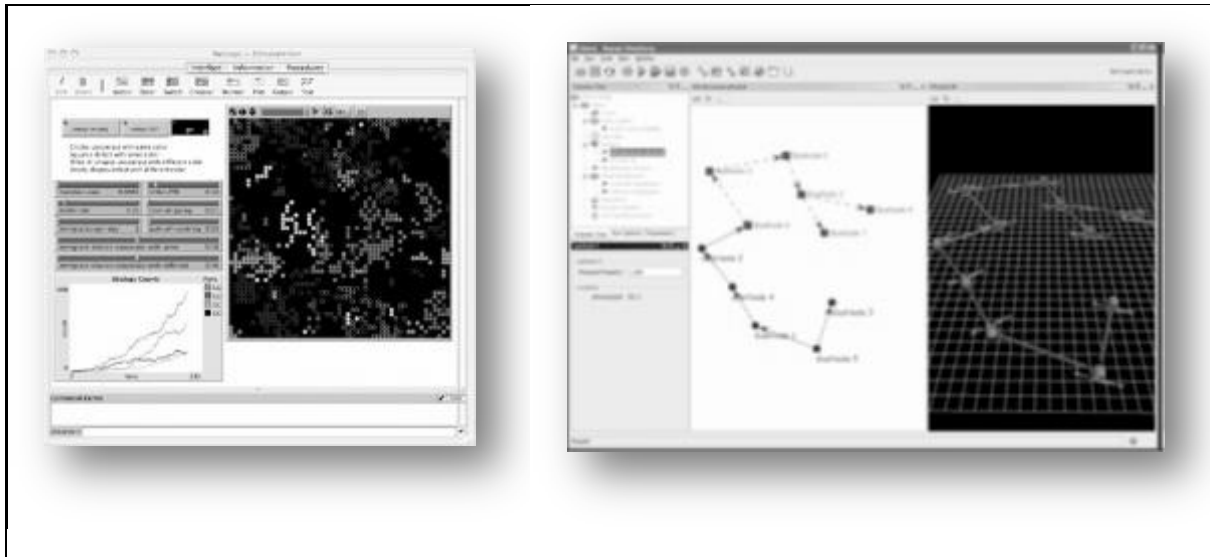
The reasonableness of using this method lies in the possibility of long retaining the calculated and coordinating contexts, creating certain abstractions for the interaction of agents. Regarding direct interaction models, the coordinating unit is transferred from the agent to the infrastructure. This approach is created essentially in two ways: in the development of the dialect of coordination and framework to improve the convenience and usability; and the displaying and execution of conveyed information recording spaces. (Pike, Lubell, 2016) .



(Pike, Lubell, 2016)

**Fig.2.9 Simplified scheme of interaction-mediated environment in which the spatial structure of the environment plays a key role in determining the perception of agents and their ability to interact with each other.**

While models of circuitous connection produce relics for operator cooperation, mirror genuine solid certifiable articles, another approach makes an impersonation of the specialist condition, considering its spatial highlights (see Figure 2.9). In this approach, operators are situated in a domain whose spatial highlights are unequivocally spoken to and influence their recognition and communication - that is, on conduct (Pike, Lubell, 2016). The idea of discernment, which is theoretical in the model of direct cooperation and has little in a similar manner as the material world (operators have their own "mind-set", which changes because of the information got as new realities in their insight base) is related with a more clear demonstrating called " a neighborhood perspective. " truth be told, these methodologies permit the presentation of frameworks for the correspondence of operators, enabling them to "feel" the condition of the earth (and in addition adjacent neighborhoods). Operators are likewise ready to change the condition of nature by framing signals like physical marvels (for instance, pheromones), or fields, or basically watching the activities of different specialists and responding to them as per the "Certain Behavioral Communications. Nevertheless, in every one of these cases, the organizing capacity of nature is critical, as it figures out what the operator can see in the present area and how it can truly change the earth, to what degree its activities can be seen by different specialists cooperating with it (Frag, Lyons, 2012).



(Crockett, Hare, et al., 2016)

**Fig. 2.10 Screenshots of NetLogo (left) and Repast (right)**

**Platforms for creating ABM**

In view of the active development of ABM, it is not surprising that there is a growing interest in software (software), which allows creating such agent models. Such software often offers the user abstractions and mechanisms for identifying agents and their environment for maintaining interactions, as well as additional functionality, such as monitoring the simulation (i.e., tuning, configuration, monitoring progress), as well as visualization, monitoring and data collection of dynamics.

The first category of platforms has universal tools that allow generating agents in the form of passive abstractions, that is, system elements controlled by the process itself. An example is NetLogo (see Figure 2.10) - a dialect of the Logo language, designed to simulate the phenomena of a decentralized and interconnected nature. The program calls individuals not agents, but turtles; a typical model consists of a cycle that selects and executes operations for each turtle in accordance with a particular situation and state. It is important to note that turtles cannot be called agents, since they almost do not have autonomy. A simple programming language that almost does not require knowledge in the field of computer science, as well as the ability to compile models in the Java language and the availability of simple but effective visualization tools have made NetLogo extremely popular (Innocenti, Lattarulo, Pazienza, 2013). There are other dialects of the Logo language (StarLogo, Starlight, etc.), but they are of no interest from the point of view of the requirements presented above.

The second category of platforms has the same goal as the first, and even offers similar tools, but such platforms are created in universal programming languages (mostly object-oriented). RePast (Fig. 2.10) represents a successful implementation of this category, and is a platform for creating ABM in the Java language. It allows you to make agents more autonomous and more relevant to your definition, as well as to control the mechanisms for changing the state, actions and choice of actions within the agent classes. The choice in favor of a universal programming language on the one hand

makes it difficult to write models by inexperienced programmers, but on the other hand it simplifies the process of integration with existing external libraries. TORePast can easily connect the tools of statistical analysis, visualization, monitoring and even Geographic Information Systems (GIS) (Imaz, et al., 2014).

The aforementioned functionality is, of course, important for simplifying the development of models, but even if the platform used previously can be adapted, it should not be forgotten that due to the independence of agents created in it, adaptation must be done in advance. The platform forms abstractions and mechanisms for agents, their decision-making methods, environments and the ways in which they interact, but the developer must in turn create technical support to be able to successfully use the platform (Efthymiou, Antoniou, Waddell, 2013).

In addition, this platform, in fact, is not capable of giving agents the ability to think and create the infrastructure of any interaction models (it is important to note that all the above platforms usually have support for determining the agent's environment, for example, a grid or chart structure). As in the previous case, there are many additional modules that allow you to perform the above tasks - from the Swarm module written in Objective- to the Java- based Ascape modules and Mason. All these modules have common algorithms, even if they differ in the platform / programming language and the technical / implementation details.

The third category of platforms is represented by attempts to create more intuitive interfaces. For example, the latest version of RePast has an interface that operates on the "point and click " principle. It also provides the ability to select from the agent's behavior list based on the basic agent behavior modules. There are also platforms designed to model specific agent models, approaches, and even specific areas of research (Hsu, Lander & Zhang, 2014).

## 2.7 PROSPECTS

Despite its young age, ABM is widely used for analysis, modeling and simulation of complex systems. A variety of approaches, modeling methods, programs, and the use of ABM in various disciplines are factors that have made ABM widely applicable. This approach allows us to unite the efforts of researchers to solve many epistemological problems, typical for the analysis and modeling of complex systems. In the future, this direction is aimed at obtaining results from a comprehensive study of certain areas. In addition, another aim of the ABM is to attempt to "bridge" between individual research results, in order to achieve a more general understanding of how an agent-oriented approach to modeling can be used effectively for studying, explanation and prediction of the behavior of complex systems.

## 2.8 CONCLUSION

The researcher has been trying to make a connection between simulation in the Lebanese context. On the one hand, formal definitions are based on the allocation of a subclass of simulation models based on the relationship between model structures and the modeled object. On the other hand, definitions of simulation modeling, whose meaning is reduced to the meaning of English phrases "simulation" and

"computer simulation", are becoming increasingly widespread. This definition of simulation modeling does not come into conflict with a more general system definition, it means a narrower range of problems solved with the help of models. First of all, imitation models are computer systems that can display changes in simulated objects in time (Hsu, Lander & Zhang, 2014).

Under the simulation model in this research is meant a computer program that displays the behavior of the simulated system in time. Also, the word "model" means any description of the essential logic of the operation of such a program using any commonly used means: state diagrams, flow charts, event diagrams, and the like (Whalen, Páez, Carrasco, 2013).

The object of research in this research is the model of the behavioral choices taken when choosing a mode of transportation. This can be part of a more general agent model of the transport system, which in turn is the result of the modeling environment of transport systems. This understanding allows us to speak of a complex description of the algorithms of the functioning of agents in models of transport systems as an agent model. The key for setting the simulation model is to determine the mutual influence of its elements. In simple cases, such an influence is given by mathematical expressions, but models of complex systems often contain algorithms for calculating the state of dependent objects as independent. At present, computers are used to create, store and distribute ideal models, which provide convenient tools that increase the flexibility, speed and visibility of model development. The concept of a modern simulation model almost completely coincides with the concept of a computer simulation model, since it is often not possible to develop a model reflecting the complex dependencies of elements without using a computer. The computerization of the work of design engineers of models led to the orientation of modern simulation for the construction and use of computer models (Górecka, 2016). Thus, the theory of simulation is closely intertwined with the theory of algorithms and the theory of software development. In this research, the term "simulation model" will mean a computer simulation model, unless otherwise explicitly mentioned.

Simulation modeling is the process of developing an imitation model of an object and investigating its properties by examining the properties of the model. From this definition of modeling it follows that this process is divided into two main stages:

The development of the simulation model begins with a detailed description of the subject area. The purposes of modeling and choosing the most suitable formalism, based on which a formal description of the modeled object is constructed. Then the system of modeling is chosen, and the constructed formal description is formulated in the form of constructions of the input language of the system (Górecka, 2016). At the last stage, the model is tested and its adequacy checked. 2. The study of the model and the interpretation of the results obtained from the point of view of the purpose of modeling are based on the data obtained during the experimentation with the model. Experimentation begins with setting the initial data. After this, the process of execution of the simulation model starts, during which the necessary information on the work of the model is collected.





# CHAPTER THREE

## Methodology and agent-based model for mode choice behaviors



## **CHAPTER THREE: METHODOLOGY AND AGENT-BASED MODEL FOR MODE CHOICE BEHAVIORS**

### *3.1 INTRODUCTION AND OVERVIEW*

This chapter centers on evolving the research methodology of the study. It helps us about how to formulate a plan that can give us an effective initiation of the study and then lead to the point where we can deduce productive results.

In the selection of research methodology, aims and objectives of the study have been given extra attention. Moving ahead, the chapter will clarify the research design of the study, explaining the nature of the study and its sub divisions.

Even though we consider that the preceding chapter explains every key term included in the study, there are still probabilities that after excessive reading, readers might lose the association. Therefore, this chapter will explain the key terms related to the study and those who are the study variables. After briefly explaining the research propositions of the study, the chapter will answer queries regarding the research model employed and its design. As it is almost impossible to survey the entire population, we have thus drawn a sample from the population that is a true representative of its field. We have written detail about sample composition and criterion related with it.

### *3.2 RESEARCH AIMS AND OBJECTIVES*

The Primary rationale for stating the aims and objectives is to identify whether the designed methodology is in sync with the aims and objectives or not. Scholarly opinion of Saunders *et al.* (2005) and Burns (2000) detail that the aims and objectives of a research play an important role in designing the research methodology. The study aims mainly at finding out the preferred mode of transportation for people of Lebanon. For this type of study, the most useful, appropriate and contemporary method for analysis is a survey in which data is collected from the population. The study has incorporated compact frequency, cross tab, non-parametric methods, and multinomial logit in finding the contributions.

However, to analyze the subject matter more critically we divided the objectives of the study in six categories.

The first objective is to build a conceptual clarification of agent based modeling and economic and social behavior factors of study. The second objective is to see the factors responsible in choice of transportation. One of the primary objectives of the study is to see how developing countries; people choosing private transport over public transport have affected especially Lebanon. However, a key consideration that has been kept in mind while commencing this study and is prioritized, as a primary objective is to ensure that the government and planning bodies can devise results and offer solutions on how people would prefer using public transport.

Therefore, the research has made a noteworthy contribution by giving factors to all involved bodies in an area where there is a lack of sound established theory. The methodology and the analysis explain it in much greater detail.

### *3.3 RESEARCH PARADIGM AND USE OF QUANTITATIVE RESEARCH*

Research paradigm is a way of properly conducting a research. Scholars emphasize the importance of drawing the appropriate paradigm and philosophy for the study (Henning et al., 2004, Gliner and Morgan, 2000). The literature recommends that these scholars are of the opinion that a paradigm is a broader umbrella covering set of beliefs, value and directions that influence any study. It is where researcher exploits on existing scholarly viewpoints, tests his knowledge and produce results that are useful for planning bodies.

When we mix social and behavioral sciences into our study, research paradigms cover numerous philosophies, like those of positivists, phenomenologist and realists. We have based our study on the philosophy reinforced by positivists. According to this philosophy, human behavior is a complex phenomenon that cannot be understood in an easy fashion by merely relying on theories; statistical evidence or any material support is necessary to gain a better understanding of it. As Eisener and Day (2004) argued that empirical evidence should be provided before siding for or against any results. We are residing in a social world that is man-made, not vice versa. Hence, having a generous proof to support or oppose ideas is crucial, as it is human ideas that ultimately set social arrangements.. Further, Saunders *et al.* (2007) are of the opinion that positivists stress on perceptible movements and development that are established as a result of some empirical research.

Hence, while studying ideas that has lately been an active part of human behavior and can be found in people from all parts of the world, it is necessary not to take any risks. Especially, when research is done with a purpose that it will become a window to show the state of affairs in a country, it becomes necessary to leave least possible space for doubt or error. Therefore, the positivism seems to be more suitable choice for this study as a research philosophy. Therefore, the major part of this study has been conducted in a quantitative way and final findings are based on data collected from respondents through a questionnaire. The data collected by us is analyzed using different statistical tools.

### *3.4 RESEARCH DESIGN AND PHILOSOPHY*

Defining research approach is significant as it is fundamental towards deciding the nature of the study. Literature guides that there are two types of research approaches; deductive approach that is applied in quantitative studies and inductive approach that is applied in qualitative studies (Bryman 2001; Collis and Hussey 2003;). Research approaches with most widely followed philosophies in the field of behavioral and social science, philosophy of positivism is well supported by a deductive approach. However, inductive can be helpful while pursuing phenomenologist's philosophy (Burney, 2008).

Flick (2009) clarifies deductive research approach as a course whereby researchers develop a theory or hypothesis or propositions and then validate it using numerical values and statistical data.

For this study, we have chosen to follow a deductive approach. Since, the research is quantitative in nature and is statistically presenting each trend, Therefore, we found the application of the deductive approach to be more suitable. This approach becomes more relevant as the research circles around studying the cause and effect relationship between various facts in numerical figures (Monette et al., 2008). Thus, it can be said that applying this approach, we create a plan that leads towards the conclusion in a very systematic order.

Apart from this, the research is exploratory in nature. This makes it a study that explores, describes and examines relationships. We relate descriptive methods to clarify these explorations. However, it is necessary to clarify concepts when doing an exploratory study (Ethridge, 2004). In this particular case, it will explore causes that make people chose one means of transportation in Beirut. Another important dimension to state regarding the research design of the study is its classification as a cross sectional study. Almost every researcher keeps this aspect in consideration, but only few mentions it downright and also explains its significance.

As per the time frame, the study is cross sectional. In such studies, the research is conducted in one time frame without any gaps; therefore, it is with chronological static and spatial dynamics. It is like a capture of contemporary practice and behaviors as practiced in many developing and developed parts of the world. Some studies require that data should be collected at different times to reach a conclusion, so in that case, the research becomes longitudinal studies. Since this study was conducted on measuring the economic and social behavior factors that helped people in taking decision regarding their mode of transportation, so the cross-sectional approach was the ideal option.

### *3.5 RESEARCH SETTINGS*

This study is confined to one geographical location. The data has been collected from people in different places but only in Beirut, through a survey. The city Beirut was choosed to meet the request of my company who is financing my PhD to do the study in this particular city. Most of the people in the population sample include people who were working in Government authorities in Beirut. They were randomly distributed and one person might fill it for himself and his family or just for himself. The data were collected between April 2017 and October 2017.

### *3.6 UNITS OF ANALYSIS*

The unit of analysis articulates the level from which the data has been collected and that the main analysis has been done for that level or unit. Therefore, a unit of analysis in a research can be a person or individual, group, community, organization or an entire country. Since the aim of the PhD research is to find the economic and social behavior factors that determine the choice of mode of transportation, so the unit of analysis for this study is individual.

### 3.7 AGENT-BASED MODEL OF THE INDIVIDUAL BEHAVIOR FOR TRANSPORT MODE CHOICE

The organizational approach is now seen as an approach suited to the analysis and design of complex systems. Indeed, agent-oriented methods have evolved from an initial vision where the system was essentially agent-centric and its individual aspects, to a vision where it is now seen as an organization in which agents form groups and hierarchies, and follow specific rules and behaviors (Argente et al. 2006). The evolutions of the methods GAIA (Wooldridge et al. 2000, Zambonelli et al. 2003) and TROPOS (Giunchiglia et al. 2002, Kolp et al. 2006) are elsewhere the most obvious examples. For the most part, agent-oriented methods admit that an multi-agent system can be conceived as an organized society of individuals in which each agent plays specific roles and interacts with other agents (Jennings 2000, Zambonelli et al. 2003). In this section, a model of the individual behaviors for transport mode choices is proposed. This model is based on the concepts of roles according to the metamodel of the ASPECS methodology (Cossentino et al. 2009).

In the mobility system, the roles of the entities are shopper, student, internal tourist or any external tourist. All of these roles have their own properties and their own behaviours, as illustrated by Fig 1.

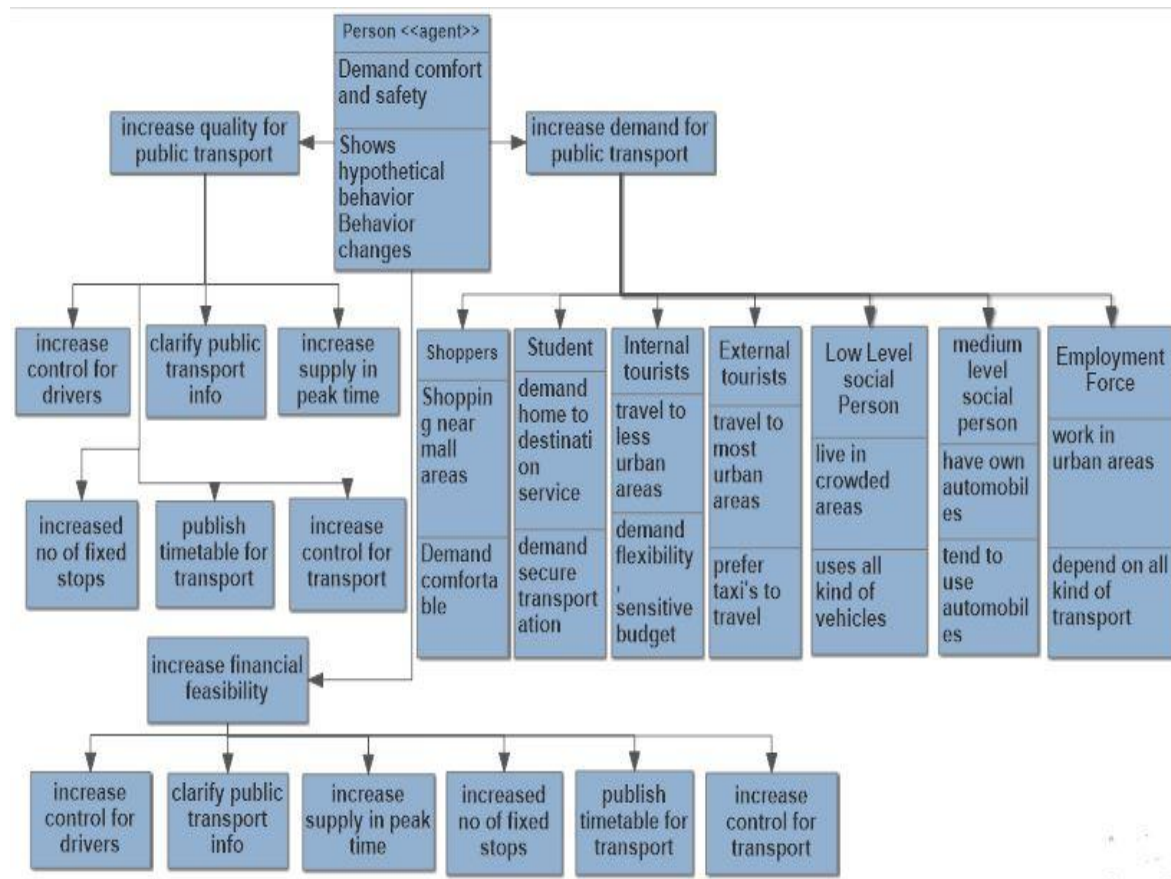


Figure 3.1 Agent-based Model of Individual Mobility Behaviors

In the mobility system, the entities may be shopper, student, internal tourist or any external tourist. All of these classes of a person have their own properties and their own behaviours, as illustrated by Fig 3.1.

### **Shoppers:**

The shoppers are referred as people who go to the mall for shopping. They can also be the workers of the mall, so they can have scheduled rides for them. They have two main categories. First they can be active users, or they can be the seasonal users. The active users may use the transport on daily basis, and the seasonal users may use it occasionally.

### **Students:**

For students, the main concern is the scheduled timing. Every student has his/her scheduled timing to get a trip. Students avail the trip on their time to attend their institutes or to return from the institutes. They also have the fixed destinations to travel. Unlike others, the students are required to be picked and dropped at the fixed destinations all the time. They students always have less financial capabilities, so their price factor is always sensitive. Secondly students need secure transportation tools at all times. They use either the buses, or their parent's automobiles to travel.

### **Internal tourists:**

By internal tourists are local residents of a certain area, but they always plan tours in their own city. They are mostly active on off days towards the less urban spots. They need a reliable transport, so they are sensitive in their selection of transportation since they are aware of the local traffic conditions. They prefer public transportation when travelling to city centers and during rush hours; however, they prefer private transportation in all other cases.

### **External tourists:**

External tourists mean people from abroad, who are on a visit to the city. The external tourists are not always aware of the routes of the city, so they usually use maps to travel through the city. They do not know how to find a specific space; they are unaware of the transportation system of the place, so they are relatively not price sensitive. They have flexibility in choosing the place and time. They prefer using taxis or ride-sharing to travel around because of comfort.

### **Low Social level People:**

The low social level people are those who live in crowded areas. They are low on resources, so they use the buses or the motorcycles for their transport mean. They can't afford the expensive taxis and don't typically ask for specific transport. They use all types of transport without any hesitation.

### **Medium Social level People:**

The medium level people have their own means of transport usually. They care about the price and quality for the transport. They prefer using their own vehicles.

### **Employment force:**

It refers to people work in the urban areas. They use the scheduled rides mostly. By scheduled rides mean they usually have the same timings to travel back and forth.

For this category of travellers, parking is the main problem. Even though they have their own means of transportation, but because of the challenge of parking, they don't always use their own vehicle for travelling. They depend on all kinds of transportation depending on the time, day of the week and destination.

In our model, all the types of entities mentioned above are supported by agents. Indeed, these entities take mobility decisions autonomously, based on their perception of their environment. This general behaviour fits the definition of a software provided by (Ferber 96).

There are some objectives and assumptions which are to be achieved in the region:

The number of fixed stops and the destination should be increased to increase usage of public transport.

Public transport should be more clarified to the people so that more and more people may get interested in using the public transport system, as it is a better and cheaper option to travel.

There should be a fix timetable for the public transport, and this timetable should be easily available, so that people can know when to avail their suitable transport.

During peak hours, the supply of the public transport should be increased so there is no shortage of travel space.

Another objective of the simulation model is the financial feasibility of the public transport. To increase the financial feasibility, the following is the set of events that will be taken into account in the simulation scenarios:

Increase the fuel price, so that the transport mean can earn more by loading passengers, and then they can fulfil the above mentions needs.

Certain traveller discounts should be made available, such as for the handicapped, senior citizens and students.

The imported cars should be charged more custom to increase the financial support of the government.

The public transport prices should be under the control of the government. The government should take over the public transport, and should be assigned the responsibility to handle the public transport and its budget.

The parking prices should be increase, so that the private transport should pay more parking fee to park their vehicles. The people using their own vehicles should also pay much to avail the parking services at the public places.

Taxes on private car ownership should also be increase to encourage people to use the public transport.



ABMS is efficiently being applied in many territories. Cases of usage include demonstration of : team working, organizational behaviour and psychology, supply chain management and logistics, social networks, consumer behaviour, distributed computing, environmental study and transportation management Operator based representing devices can be applied to test how variations in individual practices will affect developing general conduct of framework (Epstein & Axtell 2007). ABMS has additionally been linked to diverse spaces in social and society reflects, including populace development, the spread of plagues, organic applications, human progress progression, and armed applications. Macal and North have branded these ABMS applications into two taxonomies;

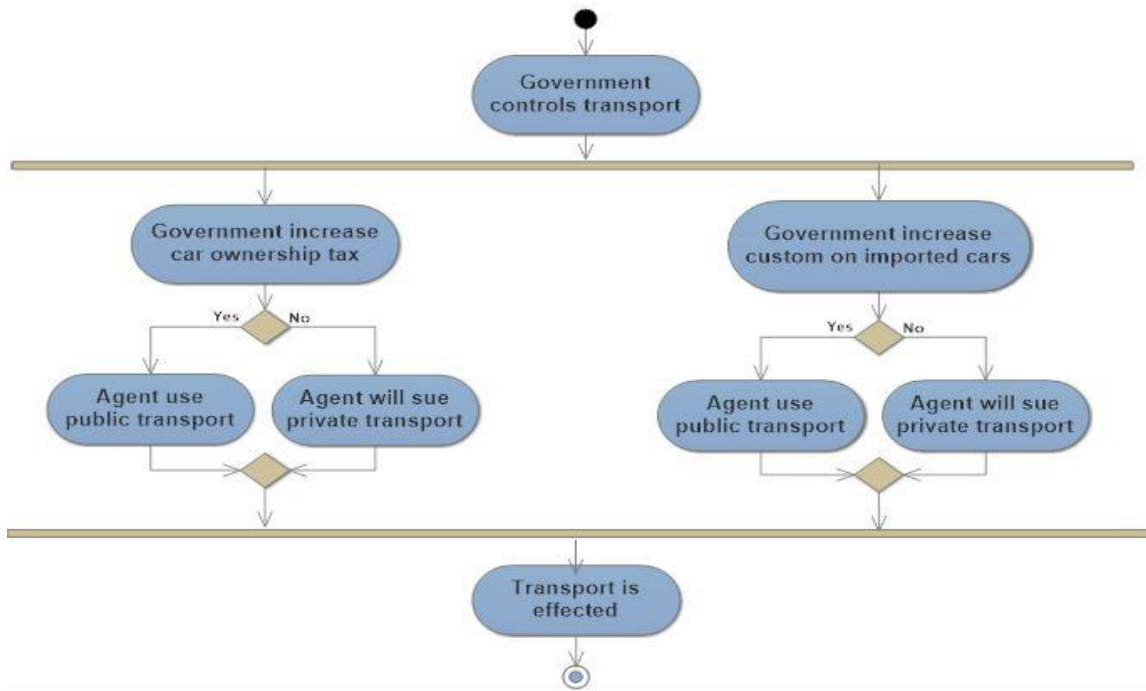
Small, delicate, moderate models: Simple models depend on a preparation of admired beliefs, envisioned to latch just the most distinguished components of an outline. These are probing electronic labs in which a widespread variety of beliefs can be altered over uncountable imitations.

Large-scale choice helpful networks: Decision boost models have a propensity of significant applications, envisioned to answer a wide possibility of policy-framework queries. These models are documented by including honest information and having approved some level of endorsement testing to set up rationality in their outcomes. A brief description of these applications has been précised with this.

Unbelievable scenarios for agent based modelling are not just result of the knowledge picked up with multi agent imitations, the convenience of easy to use reproduction phases, more remarkable computer control, and improved awareness methods. A number of exemplar shifts are also predictable. The sociologies are currently meeting a move from poor information to a rich information situation. This permits one to settle or misrepresent models, regulate their limits, and to move to information determined displaying methods (Henderson, Storeygard & Weil 2012). Furthermore, it will be imaginable to improve the level of detail, precision, and scope of agent-based models by desires of greatness. In the interim, on explanation of the convenience of easy to use regeneration gadgets, the progression times for multi agent renovations will shrink meaningfully.

The operation of techniques from quantifiable material science and the theory of complex outlines to financial information produces an option of moving past informative models towards logical prototypes. The improved information circumstance boosts the insight of the inward influences and notable examples of complex frameworks.

New possible consequences to mine constant information make the chance to change from approximations with a delay, for instance, the outdated methods for determining the overweight national product or the amount of individuals, who have this period's flu virus, towards reliable continuing assessments. Besides, using specific belongings of spreading events in systems, it seems to be even imaginable to achieve two-week predictions (Henderson, Storeygard & Weil 2012). All the more mostly, reality mining will inspire multi-agent imitations of practical circumstances, the declaration of model limits on the fly, and the fitting pledge of guidance ahead of time symbols. It will similarly desist from dislocating stays and to enlarge the efficiency of substitute reaction events.



**Figure 3.2 : Effects of government control for car ownership tax and customs on imported cars**

In Figure 3.2, the price elasticity of demand is described as if the government increases the car ownership tax on vehicles, the agents start to use the public transports. As the government charges more and more taxes on the cars owned by people, the agents will not be interested in using their own vehicles, so they will switch to public transportation.

Secondly if the government don't increase the tax for the ownership of cars, the agents will continue using their own cars, as it is a better way of travelling with ease.

Another factor will be the custom on the imported cars. If the government increases the custom charge on the imported cars, the agent will start to use either the local cars, or public transport. If the government doesn't add taxes to the imported cars, the cars will not be charged much, then the agents will start to use the imported cars, and the demand for the public transport will be decreased.

The defined work is grounded on agent-based simulation (ABS). ABS is a minute methodology for defining multifarious and dynamic systems. Because of the comprehensive arena of application, ABS is widely held for inquiries of diverse research problems. Henceforth, it is an interdisciplinary method that frequently touches numerous research fields. If ABS is used for modeling multifarious economic systems, for instance, business and customer model analysis, it is also named agent-based computational economics (ACE). Particularly because of its foundation on separate decision-making, ABS is also used in the field of transportation demand simulation.

### 3.7.1 AGENT-BASED MODELING FOR ROUTE CHOICE BEHAVIORS

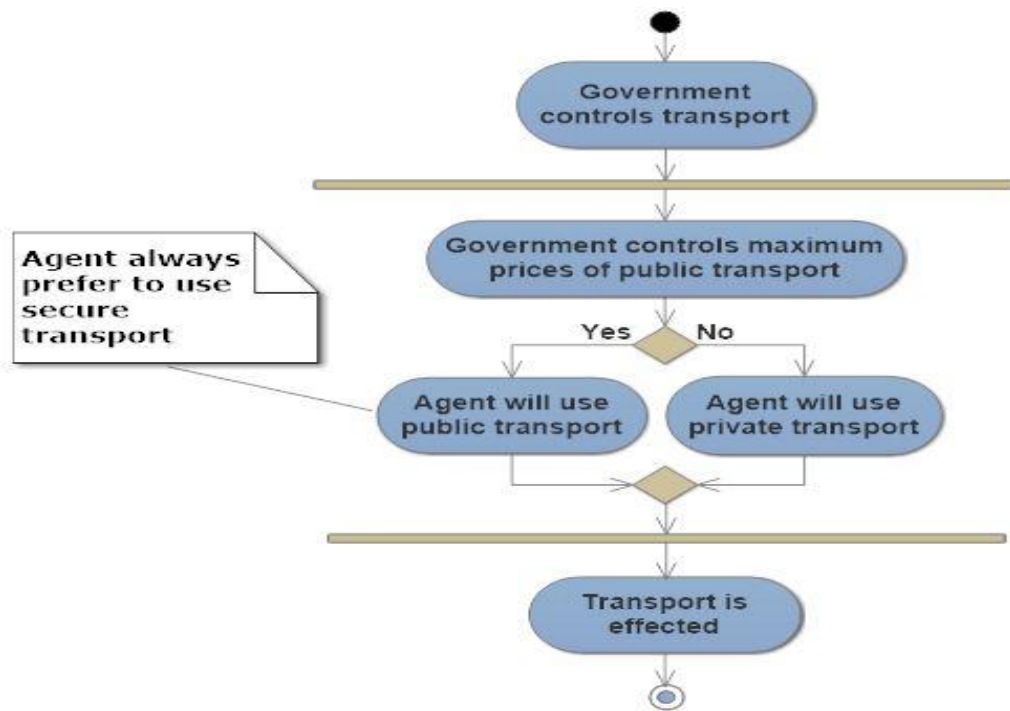
The benefits and strength of integrating ABMS to observe route choice behavior of travelers, rather than the outdated route choice models, comprise the ability to:

- Capture a specific traveler's coherent and illogical conduct and inclinations that are tough to calculate or measure in the outdated route choice models.
- Identify and ponder that travelers have dissimilar socioeconomic possessions, travel practices, partialities, way of reaction to the in route information, etc., and thus show heterogeneity.
- Capture the communication effects and joint performance that stalk from travelers' heterogeneity.
- Identify and ruminate that travelers may have imperfect information about issues such as traffic circumstances, occasions, and climate conditions; hereafter, ABMS captures the haziness of driver behavior, not like separate optimal models that assume drivers are always balanced with faultless admittance to full information.
- Allow travelers' choice and information to be efficient on a real-time base, rather than on a day-to-day base.
- Articulate the mechanism of travelers' composite decision making procedure.
- Forecast travelers' sensible reply to real-time in route information or related unanticipated spur forced in the environment.
- Probably observe developing behavior as an inducement to a new environment system.

### 3.7.2 RELATIONSHIP BETWEEN THE PRICES OF THE PUBLIC TRANSPORT WITH THE USAGE OF THE PRIVATE TRANSPORT AND PUBLIC TRANSPORT

The diagram reflects the Elasticity of the Demand. The elasticity of the demand of the public transport is also dependent on the maximum prices of the transport. If the government will increase the maximum prices of the public transport, then the agent wont be able to afford the public transport at all, in this case the agent prefers to use the private cars. So there is an inverse relationship between the maximum prices of the public transport, and the prices of the transport.

If the government will decrease the maximum prices of the public transport, the agent will start to use the public transport, and the use of private automobiles will be reduced.

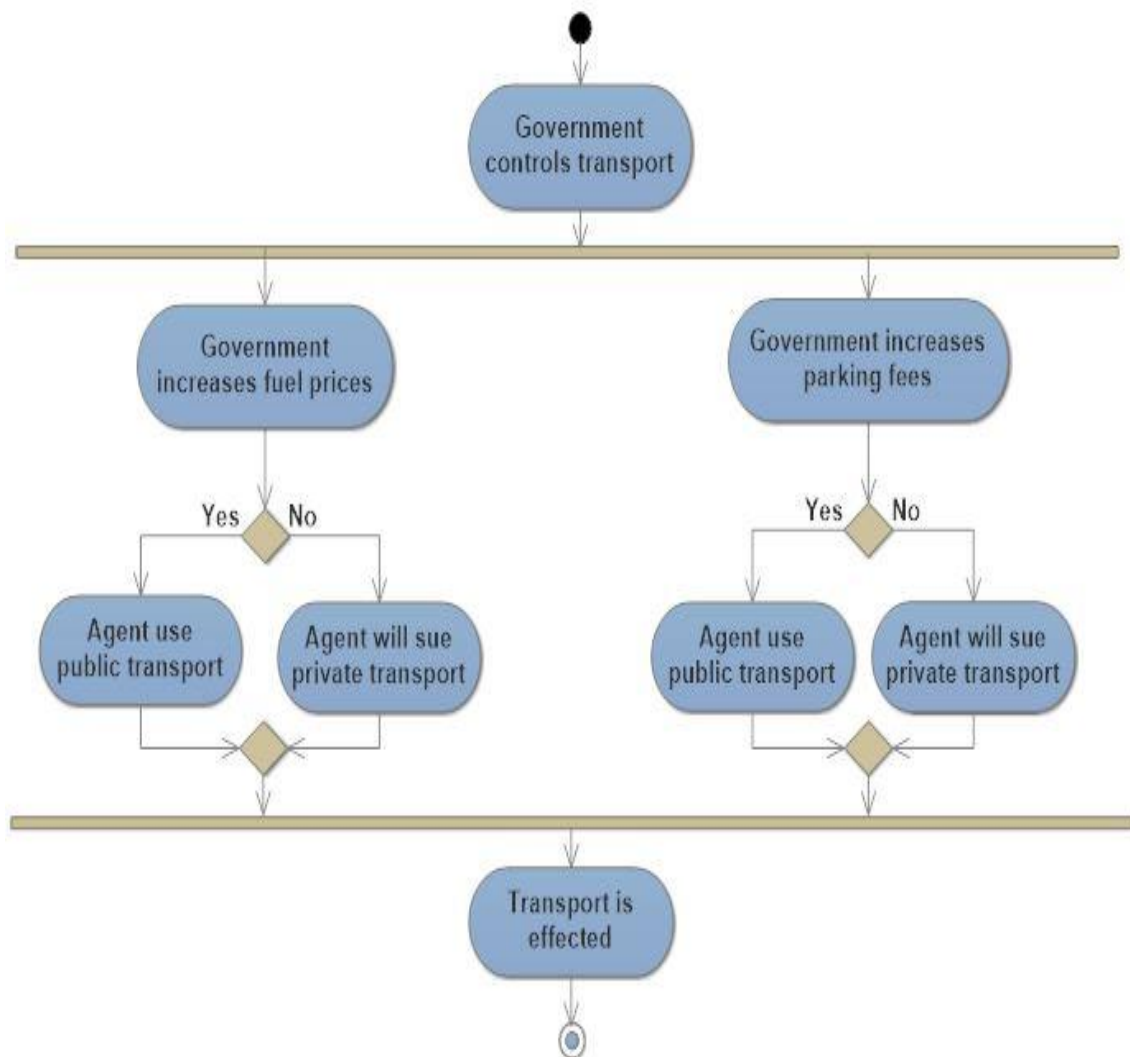


**Figure 3.3: Effects of governmental controls of public transport prices**

### 3.7.3 RELATIONSHIP BETWEEN THE PRICES OF THE FUEL AND THE PARKING FEE WITH THE USAGE OF THE PUBLIC TRANSPORT

The Cross price elasticity is also a factor between the prices of the fuel, the prices of the parking and the usage of the transport. There are two main cases:

- If the government increases the prices of the fuel, it will cause the agent to use the public transport. The increase in the fuel price will affect the usage of private cars. This will eventually change the preference of people to public transport.
- Secondly the parking prices also have an affect on the usage of private owned cars. If the parking charges are set higher in the areas, the usage of private cars will stop. They will prefer to use the public transport as it doesn't require any parking fee.



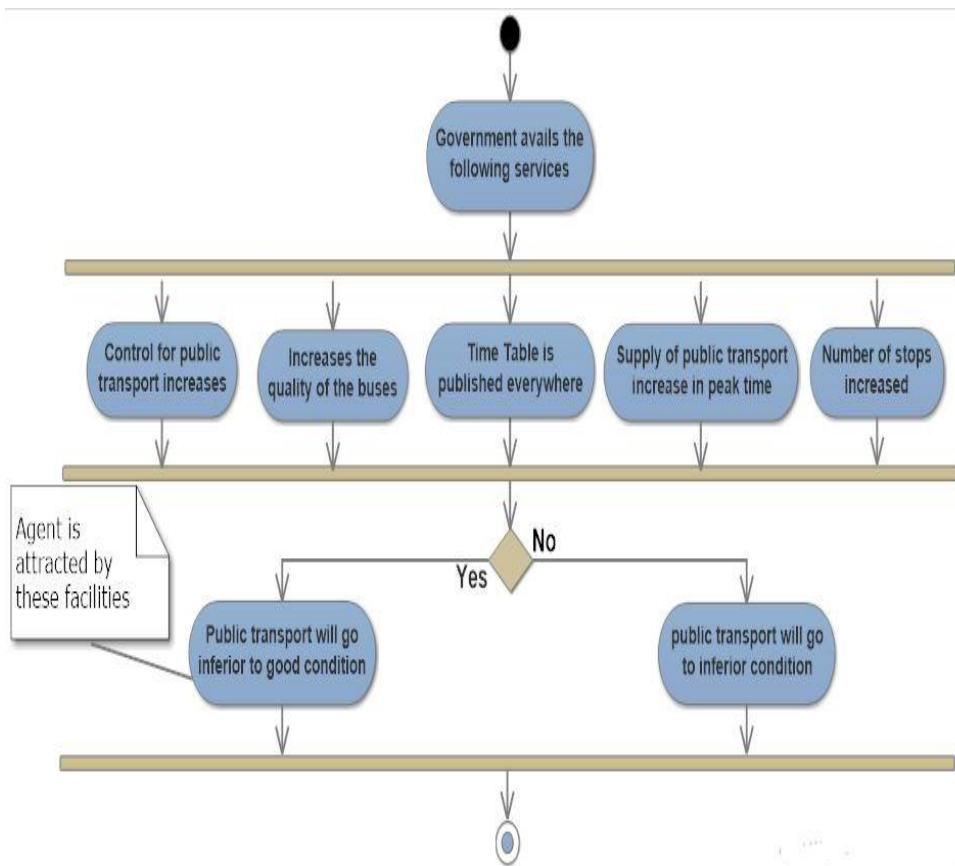
**Figure 3.4: Effect of government control of fuel and parking fees**

### 3.7.4 FACTORS THAT SHOW NEGATIVE AND POSITIVE EFFECT ON PUBLIC TRANSPORT

There are certain factors discussed here in detail that can influence the decision of using either the public transport or private:

- The fixed number of stops and destinations can help in increasing the usage of the public transport. If the stops and destinations are increased, people will prefer to use the public transport, so they can travel to more and more places through the public transport.
- If the timetable for the transport is maintained properly, then people will use the public transport for travelling. If proper information about the timings of the public transport vehicles is disseminated, people will use these vehicles for travelling.

- If maintaining the above factors increase the usage of the public transport, then there is a need from the government increase the supply of the public transport. If the usage of public transport increases, there will be a need to increase the number of vehicles also. In this way government will need to increase the supply of the public transport.
- To maintain the public transport, the information about the public transport should be easily available. The information should be displayed on the public places so that people may get the proper information about the public transport vehicles, routes and timings.
- Finally, the public transport usage can be increased by increasing the reliability of the transport which means the transport quality should be increase. The buses should be clean and comfortable and also on time. The comfort with time and space will influence people to use the public transport more.



**Figure 3.5: Effects of government avails for some services**

### 3.7.5 POSITIVE STEPS TO INCREASE THE USAGE OF PUBLIC TRANSPORT

The usage of public transport also increases once the government starts subsidising the public transport. It decreases the overall cost of usage to the people. This in turn increases the chance of usage because of affordability. However, if the government is not subsidizing the public transport, due

to increased fuel prices, the affordability of public transportation is reduced which influences people to use the private transportation more.

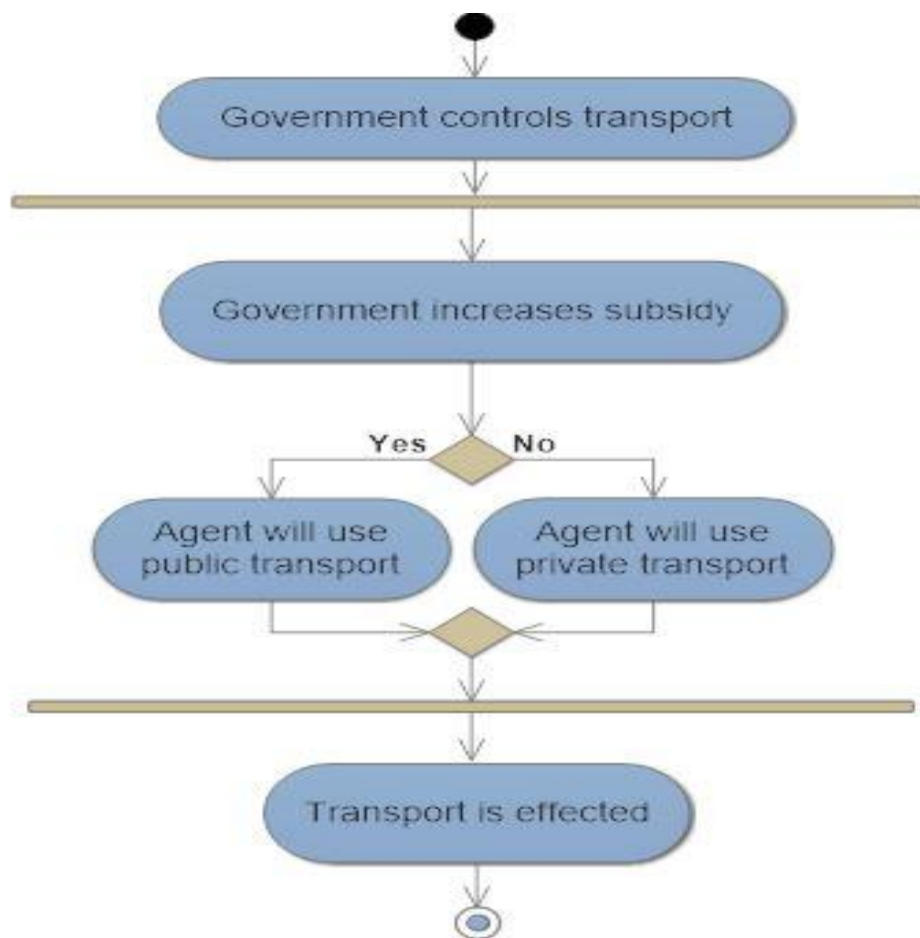
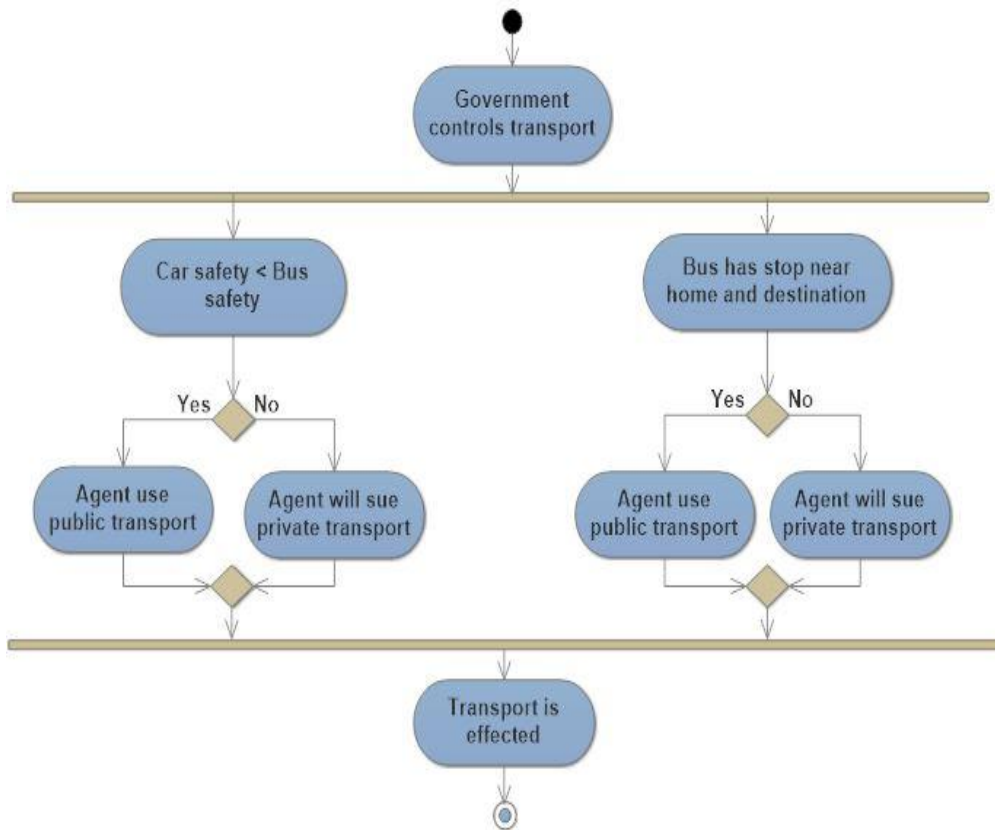


Figure 3.6: Effects of government controls for subsidy



**Figure 3.7: Government controls for car safety and stops**

### 3.7.6 SAFETY MEASURES AND ITS EFFECT ON PUBLIC TRANSPORT

Above is a safety paradigm for passengers. Safety in the cars is lesser as compared to safety in the bus. The usage of public transport is much safer than the usage of personal cars. Moreover, there are certain facilities that the public transport offers. Like, picking up from a designated spot and dropping at your destination without the strain of driving, stress of traffic and the travel time is the same on average.

### 3.8 CONCLUSION

This chapter mainly focuses on the establishment of research model that will be used for the study. The research model has been presented and explained in a detailed manner. The proceeding chapter will develop the hypothesis and provide descriptive results related to it.





# CHAPTER FOUR

## Hypothesis development and framework for the study case



## **CHAPTER FOUR: HYPOTHESIS DEVELOPMENT AND FRAMEWORK FOR THE STUDY CASE**

### *4.1 INTRODUCTION AND OVERVIEW*

The previous chapter focused on developing the research model and portrayed a model based on Agent Based Modeling. The current chapter will develop hypotheses related to the research and model and will present descriptive findings related to different variables.

### *4.2 HYPOTHESIS DEVELOPMENT*

This study is designed to gain a better understanding of choice of mode of transportation in Lebanon. The study aims at exploring the nature of the economic and social behavior factors that determine the choice of type of transport a person uses. We are more interested in knowing how it will influence planning at government level. If a person is always choosing private transport over public transport, it either saves time or money. Also, there is a chance there is more convenience in using private transportation or the state of affairs of public transportation is not good enough.

The model represents that the choice of mode of transportation is dependent on the profession of a person. Your occupation determines the amount of money you are making. If you have a well-paid profession, you will choose luxury and comfort over more things and will place more value on your time. Therefore, you will be more determined to use a private transportation than a public transport.

If a person is at a high status in his profession, his decisions will be affected differently. In many organizations, transportation allowances are provided for senior professionals, which makes it easy for them to travel.

In order to successfully achieve all the study goals and address all study questions, the following research hypotheses have been formulated:

**Hypothesis 1:** Occupation is a factor in the choice of mode of transport

**Hypothesis 2:** Status in management is positively related to choice of mode of transport

**Hypothesis 3:** Type of profession is positively related to choice of mode of transport

**Hypothesis 4:** Gender is a controlling factor in choice of mode of transport

**Hypothesis 5:** Age of head of family is a controlling factor in choice of mode of transportation.

### *4.3 RESEARCH INSTRUMENT*

In order to gather primary data, many tools are available for research. The most convenient of them is the use of interviews and questionnaires. The aim of this research is to dig out information regarding choice of transportation, so the most appropriate tool is the use of survey. A survey makes it easier to quantify results of a large population, once its summarized. Moreover, large amount of data can also be collected using a survey method with less expenditure and time (Kumar, 2005).

Like mentioned earlier, this study uses a questionnaire survey. A 31-point questionnaire was distributed among the population of the study. A hard copy of the questionnaire is attached in the appendix. The questionnaire was detailed to cover all possible sections of the research.

### *4.4 SAMPLING FRAME*

While researching the preference of transportation, the questionnaire was distributed in a over 3000 people personally and virtually. The responses received were around 1640. Out of the responses received, 110 were incomplete and 120 had faulty results. Therefore, the sample was niched to 1040 people. There were no specific inclusion or exclusion criteria for the questionnaire and there was no grouping done for the sample.

### *4.5 INSTRUMENT VALIDATION*

It is necessary to do validation of a questionnaire because sometimes it is not uniformly validated across different sets of population (Hong & Kim, 2002; Amoako-Gyampah & Salam, 2004). The instrument of the study was validated by interviews and pilot study to ensure the factor and content validity. The two stages of validation are below:

#### *4.5.1 INTERVIEW (SEMI STRUCTURED FOCUS GROUPS)*

Series of interviews were piloted with 30 people. These people were from different backgrounds and had different professions. This was beneficial in order to deeply investigate the respondent's point of view, feelings and perspectives (Willis, 2004).

The respective facilitators arranged meeting rooms and set up the interview schedules. All of the interviews were recorded and transliterated. The interviewees were informed at the beginning about practices and how the data would be used, etc. Interviewees were asked to put their consent of the interviews" procedures in writing. The items for each factor were reviewed during the interviews for meaningfulness and suitability to the interviewees who would be completing the survey. Participants were asked to fill out the questionnaire, make a comment about it and evaluate the items used to measure each factor.

The primary objectives for conducting these interviews include those cited in Veal (2005), Ticehurst & Veal (1999) and Kripanont (2007) and as discussed below.

- Test the wording of the questionnaire, sequencing of the questions and layout in addition to gaining familiarity with interviewees and estimating interview or questionnaire completion duration.
- Evaluate the study model, questions, measurement items and the consistency between these elements with the model of research.
- Test whether or not the questionnaire reflects all vital concepts to evaluate the impact of economic and social behavior factors that affect the choice of transport.
- Validate the questionnaire through the flow and structure of the questionnaire, the comprehensiveness of the questionnaire and its content, the average time taken to complete it and if the interviewees are comfortable in filling out the questionnaires, and to determine whether or not the length of the questionnaire is appropriate from a respondent's perspective (Kripanont, 2007).

The study questionnaire was discussed with all participants of the interviews in an opened ended approach. The discussion was done to make sure that the factors are developed and refined and also the items measuring each factor (Blumberg et al., 2005). Discussion made in the focus group about the questionnaire before the data collection helped improve the research considerably as sources of miscalculations and misunderstanding were well handled before the study was conducted (Shank, 2006; Gummesson, 1999).

The questionnaire was later modified according to the feedback received from the interviewees. This also helped reduce the number of items per factor and evaluate the fitness-of-the-measurement factors (Lee et al., 2002). As a result, only minor changes were made and wording of some of the items to adapt and fit the context. The number of the questionnaire items also was reduced to 31 items instead of 50 items and the questionnaire was confirmed to start the pre-test.

#### 4.5.2 PILOT STUDY

Pilot testing means using the test on a reduced segment and analyzing if the research instruments and other specifications drawn from methodology are working in accordance to the benefit of the research or not. A pilot study is often considered as pre-study of the complete study.

Scholars have also classified pilot study in two categories. The first one is referred to as feasibility study that is the small scale trial-run done as a part of larger plan. The second category is pre-testing also referred to as a „trying out“ technique. This is done usually to check the validity of a research instrument. Mostly, it has been used to see the effectiveness of questionnaires and interviews.

In this study (the pilot study) twenty people, who did not participate in the interviews, were sent the modified questionnaire. They were asked to fill out the questionnaire and evaluate the study questionnaire as discussed below. An evaluation sheet was also attached with each questionnaire. The people were asked to fill out the evaluation sheet to test several criteria relating to the questionnaire. The results of the data collected from this sheet are summarized in Table 4.1 below.

Scale used: Very low	1	2	3	4	5	Very high	
Question/ statement							Means
The length of the questionnaire							3.37
The fitness of the measurement with the concepts.							4.21
Consistency in the study model and measurement items.							4.32
The structure and flow of the questionnaire							4.2
Comprehensiveness and content of the study factors							4.07
Average time taken							4.18
Overall mean							4.058

Table 4.1 Questionnaire Evaluation , n=20

Overall, these criteria have been evaluated and the assessment rating was obtained by calculating the mean of the scores for all 20 respondents. Scales were given scores ranging from “1= very low” to “5= very high”. The results suggested that each item scored 4 or higher in over 70% of the responses, suggesting that no wording revision or new items were needed in the completion of the questionnaire.

The technique has significant benefits, most importantly saving us from grave mistakes at later stages and saving the study from being disrupted. Pilot testing is an effective way to measure the performance of a research instrument and since the test has been conducted on preliminary information, it gives us enough time to fix issues and loopholes, if any. Not only this, pilot testing also gives an opportunity to cross check if the statistical technique or mode of analysis used is in line with the aim of the study or not. When researchers are piloting studies that have multiple hypotheses, pilot testing can help narrow down the list of developed hypotheses keeping only the most relevant ones in the study. At times, it is during pilot testing that the researcher confronts new ideas that can be incorporated in the study as new hypotheses or can be used as an extension for future studies. This helps in giving more depth to the study and broadens researcher’s vision on the topic (Tashakkori & Teddlie 1998). More specifically, its significance magnifies when research results are based on primary data observations.

## 4.6 STUDY VARIABLES

### 4.6.1 GENDER

The sample composition is evenly distributed between male (49.8%) and female (50.2%) with slightly more females than male. The survey was distributed in the government organizations and was distributed randomly and through reference. The questionnaire was filled up by the heads of the family, for their dependents, as well. The results clearly depict that the number of females are as much as the number of males in the workforce in Beirut because of which we have quite a balanced division of gender of the sample.

Table 4.2 Demographics of the Sample Based on the Gender (n=1040)

Gender

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Male	517	49.8	49.8	49.8
Female	521	50.2	50.2	100.0
Total	1038	100.0	100.0	

### 4.6.2 LIVING WITH PARTNER

This part of the questionnaire depicts the segment of population living with a partner. This could be in a situation of living with a person with or without wedlock. The sample distribution shows that 46% of the population is living with a partner and 54% are living alone.



Table 4.3: Population living with Partners (n=1040)

Living with partner

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	477	46.0	46.0	46.0
No	561	54.0	54.0	100.0
Total	1038	100.0	100.0	

#### 4.6.3 DESCRIPTION OF LIVING SITUATION

In order to understand family structures in a better way, we have added the question of description of living situation. It was previously categorized as Alone, without partner and with children, with one parent, with 2 parents and other. However, after pilot testing, it was found that the interviewees found the question confusing and hard to answer. Therefore, the categories were reduced to three main categories. 53.8% of the participants were living alone, 4.7 % live with children but without a partner and 41.7% live with parents. This shows that the population is fairly distributed between people living alone (53.8%) and people living with someone (46.2%) whether children or parents.

Table 4.4: Distribution of living situation

Description of living situation

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Alone	558	53.8	53.8	53.8
Without partner & with Children	47	4.5	4.5	58.3
With parents	433	41.7	41.7	100.0
Total	1038	100.0	100.0	

#### 4.6.4 DRIVER'S LICENSE HOLDERS

The participants are asked if they own a driving license in Beirut. There is a significant amount of participants (68.1%) that have a driving license. It means they can drive and they probably own a car or plan on acquiring a car in order to be able to drive.

One necessary injunction to be made at this point is that even though 68.1% of the participants own driving licenses, there is still a large population (31.9%) that do not own driving licenses. There could be many reasons involved in not owning one. First being the necessity, maybe they don't need it because they neither own a car nor plan on owning a car in the future. Second reason could be the law of the country which could be lose enough where you could drive even though you don't have a driving license. Third, the process of owning a license might be so lengthy, tiresome or expensive that people avoid getting into it and thus they don't own a driving license.

Table 4.5: Driver's license holder

Driving license holder

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	707	68.1	68.1	68.1
No	331	31.9	31.9	100.0
Total	1038	100.0	100.0	

#### 4.6.5 HIGHEST DIPLOMA OR CERTIFICATE

The education of participants tells a lot about the population. Technically speaking, the more educated the population, the more refined they are and the more they are aware of and followers of law. However, education also gives the picture of the society. In the case of our participants, 50% of the population has university degrees. This shows education is very popular in Beirut and is considered a necessity in achieving harmony. However, it also shows that life discipline is not there. If 50% ore more people have university degree and still there is dissatisfaction in life or lack of jobs, then the balance of life would be disrupted. We can see that nearly 32% of the population has secondary or lesser certificates. We can infer from the data that these people would be employed at unskilled areas of not employed at all.

Table 4.6: Highest diploma or certificate

Highest Diploma or Certificate

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Primary or less	128	12.3	12.3	12.3
Secondary & less	257	24.8	24.8	37.1
Technical or less	129	12.4	12.4	49.5
University or less	524	50.5	50.5	100.0
Total	1038	100.0	100.0	

4.6.6 HEAD OF FAMILY

The data shows that 32.6 % of the sample is the head of the family, which means that they are responsible for possibly managing the family, earning for the family and making decisions for the family in most cases.

As far as adequacy of the sample is concerned, the results are not bad. Factor analysis was also done and data adequacy was over 70%. This means that this data was worth analysis.

One more point to keep in mind at this stage is that while the questionnaire was being asked to be filled, in some cases, the heads of the family were told to fill the questionnaire on behalf of the minors. This results show that probably 32.6% if the actual sample size that filled the questionnaire on behalf of the rest of the population.

Table 4.7: Head of family

Head of the Family

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	338	32.6	32.6	32.6
No	700	67.4	67.4	100.0
Total	1038	100.0	100.0	

#### 4.6.7 MARITAL STATUS OF THE HEAD OF FAMILY

The data implies that 63.8% of the population is currently married or has been married before. This shows that the society has a system of marriage and it is encouraged to be lawfully married than living together without wedlock. There is still a significant percentage of the head of family (36.2%), which are not married. One possible explanation could be that in certain societies Males are considered to be the head of the family. In case of death of the father of the family, the sons, even if they are single, are considered to be the head of the household and thus they are responsible for most of the family affairs.

Table 4.8: Marital Status of the Head of Family

Marital status of head of family

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Unmarried	376	36.2	36.2	36.2
Married	433	41.7	41.7	77.9
Widow	27	2.6	2.6	80.5
Divorced	202	19.5	19.5	100.0
Total	1038	100.0	100.0	

This can be seen from table 4.9, that in majority cases (60.3%), the head of the family is male. Female head of the family is also a significant rate (39.7%). However, we need to keep in mind that in a country like Lebanon, the only reason a female would be the head of the family would be the death or absence of a male member.

Table 4.9: Gender of the Head of Family

Gender of Head of Family

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Male	626	60.3	60.3	60.3
Female	412	39.7	39.7	100.0
Total	1038	100.0	100.0	

#### 4.6.8 EDUCATION OF THE HEAD OF FAMILY

It can be observed from the data that 36.1 % of the Heads of family have primary or less education. This means that either they don't have access to education or they cannot afford education. Moreover, if we look at the other side of the picture, 36.6% of the population has University degrees or the like. This shows that education is not easily available to all. Lawrence curve is very deep and it is obvious that education inequality exists that can be attributed to income inequality as well. Even though there is no variable predicting that from the data set, but it can be implied from the education inequality.

Table 4.10: Education of Head of family

Education of Head of Family

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Primary or less	375	36.1	36.1	36.1
Secondary & less	136	13.1	13.1	49.2
Technical or less	147	14.2	14.2	63.4
University or less	380	36.6	36.6	100.0
Total	1038	100.0	100.0	

#### 4.6.9 USING CAR AS A DRIVER OR AS A PASSENGER

In order to understand the preference of population for a certain mode of transport, there is a need to observe their usage on a day-to-day basis. The survey asked the participants on which mode of transport they use and how frequently, the results of each mode will follow as we read through. The first of all being "car" as the primary mode of transportation.

The data shows that 38.1 % of the population uses their car on a daily basis. This is a significant amount. If we look on a weekly basis, it is 46.2% of the population that are using it a few times or daily in a week. This shows that the preference of the population is using their own cars instead of public transport.

If we look at the other end of the spectrum, 40. 4% of the population uses car as a driver few times a year. The most obvious reason for this could be not owning a car or not able to afford a car.

Table 4.11: Car as a driver

Car as a driver

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid A few times a year	419	40.4	40.4	40.4
A few times in a month	140	13.5	13.5	53.9
A few times in a week	84	8.1	8.1	61.9
Daily	395	38.1	38.1	100.0
Total	1038	100.0	100.0	

If we observe the behavior of the population in terms of using car as a passenger, it is very low (11.8%) on a daily basis. This shows that chauffeur culture is not very common in Lebanon. Most of the people prefer driving their cars. Also, it can be implied that car-pooling is not very common in the country too.

Table 4.12: Car as a passenger

Car as a passenger

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid A few times a year	348	33.5	33.5	33.5
A few times a month	339	32.7	32.7	66.2
A few times a week	228	22.0	22.0	88.2
Daily	123	11.8	11.8	100.0
Total	1038	100.0	100.0	

#### 4.6.10 USING BUSES

It can be seen from the data, that 81.6% of the population use buses either never or a few times a year. This can be attributed to the fact that the population is not used to travelling on public transportation. Also, lack of availability of buses, punctuality and lack of stops could also be some of the reasons for buses not being very popular.

Table 4.13 *Buses*

Bus

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Never/A few times a year	847	81.6	81.6	81.6
few times a month	73	7.0	7.0	88.6
few times a week	54	5.2	5.2	93.8
Daily	64	6.2	6.2	100.0
Total	1038	100.0	100.0	

#### 4.6.11 USING MOTORCYCLE

It can be seen from the data that motorcycle is also not a popular mode of transport in Lebanon. 76.2% of the population either doesn't use it or use it a few times a year.

Table 4.14: *Motorcycle*

Motorcycle

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Never/A few times a year	791	76.2	76.2	76.2
few times a month	33	3.2	3.2	79.4
few times a week	33	3.2	3.2	82.6
Daily	181	17.4	17.4	100.0
Total	1038	100.0	100.0	

#### 4.6.12 USING BICYCLE

It can be seen from the data that bicycle is not a popular mode of transport at all in Lebanon. 88.6% of the population either doesn't use it or use it a few times a year. One of the reason for this could be that distances are a lot and they cannot be covered with a bicycle.

Table 4.15: *Bicycle*

Bicycle (all kinds)

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Never/A few times a year	920	88.6	88.6	88.6
few times a month	82	7.9	7.9	96.5
A few times a week	28	2.7	2.7	99.2
Daily	8	.8	.8	100.0
Total	1038	100.0	100.0	

#### 4.6.13 USING TAXI

It can be seen from the data that taxi is not a popular mode of transport at all in Lebanon. 94.2 % of the population either doesn't use it or use it a few times a year. The reason could be unavailability, discomfort or safety in using taxis.



Table 4.16: *Taxi*

Taxi

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Never/A few times a year	978	94.2	94.2	94.2
few times a month	37	3.6	3.6	97.8
A few times a week	21	2.0	2.0	99.8
Daily	2	.2	.2	100.0
Total	1038	100.0	100.0	

#### 4.6.14 AUTOCAR

It can be seen from the data that autocar is not used in Lebanon. 85.9% of the population either doesn't use it or use it a few times a year.

Table 4.17: *Autocar*

Autocar

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid A few times a year	892	85.9	85.9	85.9
Daily	146	14.1	14.1	100.0
Total	1038	100.0	100.0	

#### 4.6.15 SHARED TAXI

It can be seen from the data that shared taxi is used but it is not a very popular mode of transport. 55.1% of the population either doesn't use it or use it a few times a year. 17.2% of the population used it a few times a year. This could be for travelling or airport usage, in order to avoid the airport parking or hassle of parking in the city.

Table 4.18: *Shared Taxi*

Service (shared taxi-q9l))

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Never/A few times a year	751	72.4	72.4	72.4
few times a month	101	9.7	9.7	82.1
A few times a week	114	11.0	11.0	93.1
Daily	72	6.9	6.9	100.0
Total	1038	100.0	100.0	

#### 4.6.16 PROFESSION OF THE PARTICIPANTS

From the data that has been collected from the survey, it has been observed that the profession of the participant has an important role in the choice of the mode of transportation. Therefore, it is necessary to understand the profession and status of the participant in order to make a relationship on why a certain mode of transportation was chosen.

As we can see from table 4.19, 42.6% of the population is unemployed. We can contribute it either to being jobless or they can be youth or underage for a job. Keeping that part in mind, majority of the population is employed, which means the trend in the country is to study to earn. There are only 11.2% of the population, which are self-employed, which shows that there is a significant lack of entrepreneurship. Innovation is lacking in the population because of which the race to work as an employee is more.

Table 4.19: Main Occupation of the Participants

Main Occupation

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Unemployed	442	42.6	42.6	42.6
Worker	114	11.0	11.0	53.6
Employee	366	35.3	35.3	88.8
Self-employed	116	11.2	11.2	100.0
Total	1038	100.0	100.0	

The status in management also plays a very important role. There is a very vague result in this regard. 63.9% of the population is in others. This can include underage, retired, students, self-employed, contractual employees etc. Since we cannot determine which sub category the “Others” fall into, so it is slightly difficult to understand the spectrum of the population.

However, from the rest of the frequencies, we can understand that there are serious problems in the job market. There is a very small percentage working as senior executive. Most of the population is in either middle management or clerical positions. This shows that the rich in the population are less and there is a higher percentage of middle class.

Table 4.20: Status in Management

Status in Management

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Others	663	63.9	63.9	63.9
Senior Executive	26	2.5	2.5	66.4
Middle Management	196	18.9	18.9	85.3
Office Worker	153	14.7	14.7	100.0
Total	1038	100.0	100.0	

Type of profession also tells a lot about the population. In most of the countries, the number of doctors or experts tells how educated or how competitive the population is. As we can see from the results, there is merely 2.8% of population, which are experts in their field. This shows that even though education is common in the country but the strive to chose difficult and competitive fields is very low. Apparently, most of the population takes on to easier fields. Moreover, the occurrence of entrepreneurs in the population give rise to better economy and improves a country overall. If we see the results, only 8% of the population is entrepreneurial, which means they are less likely to think out of the box.

Table 4.21: Type of Profession

Type of Profession

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Others	926	89.2	89.2	89.2
Professional/Entrepreneur	83	8.0	8.0	97.2
doctor/lawyer/expert/etc	29	2.8	2.8	100.0
Total	1038	100.0	100.0	

#### 4.7 DATA ANALYSIS

Data analysis is one of the most noteworthy fragments of the research where the research findings and results will be clarified. The time and effort that has been put into it is verbalized in this section.

Depending on the flora of the study and the research design that we will be following in this study, it appeared more suitable to conduct exploratory data analysis on the information gathered. In this study, as aforementioned, the data were collected using a survey and was then deciphered in statistical terms for analysis purposes. Generally software that can aid in data decoding, modeling and analysis are used for such data. Out of the many types of software, we choose Statistical Package for Social Sciences" popularly known as SPSS for data modeling and analysis. The simplicity of the software interface and range of possible analysis that can be applied in all sorts of data from the field of research makes it an appropriate choice for this complex task.

The primary data obtained via survey is analyzed by using non-parametric tests. We decided to apply this technique, keeping in mind the underlying query that the hypotheses hold. Non-Parametric tests were applied because of the following reasons that applied to the research in hand:

- ✓ Not a very large sample size
- ✓ Questionnaire survey based on Likert scale
- ✓ Some Variables have more than 2 dimensions
- ✓ No obvious relationship proven of variables from theory
- ✓ For the parametric tests e.g. regression, you have to justify certain requirements which the current data set doesn't meet. So, non-parametric tests are considered stronger in such cases.
- ✓ Another advantage of non parametric is that without prior proven theory of related variables, the non parametric test can be applied because non parametric test requires less rigid assumptions.
- ✓ Parametric tests also require linear or non-linear relationships between variable whereas non-parametric tests don't have any such rations.
- ✓ Moreover, the minimum requirement of dataset can be less than 10 for non-parametric. Therefore, results can be derived from a very small data set too.

The results have been analyzed using frequencies, cross tabulation and Multinomial Logit.

#### 4.7.1 CRONBACH ALPHA

The study has used Cronbach Alpha ( through SPSS) to check the validity and reliability of the research instrument. It statistically confirms the significance of the research instrument, i.e. Survey in our case. In relation to the inquiry regarding the effectiveness of the research instrument, Cronbach Alpha is one of the most applied techniques. Researchers and statisticians heavily rely on it. We have concluded that reliability and validity are a nonconcrete idea that cannot be achieved totally (Golafshani, 2003; Stangor, 2010). However, what can be done is to achieve the maximum standards of reliability and validity and for that the research methodology concludes to use Cronbach Alpha.

The test will be applied to data collected by distributing questionnaires among 50 respondents. After decoding the responses and applying the test, a statistical value will be obtained that will decide the reliance of the research instrument. Under this particular methodology, the criteria followed by us to affirm a research tool reliable is getting the value of Cronbach Alpha greater than 0.5. If and only if the value is greater than 0.5, the research tool will be looked up to as effective, appropriate and in line with research aims and objectives.

#### 4.7.2 DATA ANALYSIS TECHNIQUES

The entire data was analyzed through SPSS using the following steps:

- Complete questionnaires were used for the study. Questionnaires with missing values were removed from the dataset.
- Every item of the questionnaire was coded.
- All the coded data were inserted in SPSS.
- Non-parametric tests was used to find out the associations between mode of transportation and profession.
- Each result will be debated on the basis of its setting in Lebanon

#### *4.8 ETHICAL CONSIDERATIONS*

Ethics in research pertain to a code of conduct or expected standards of behavior while carrying out research (Kripanont, 2007). Ethical conduct should be clearly exposed in the performance of researchers who carry out the research and also the participants providing data, and also in the analysis of the research findings. In saying this, ethical behavior recounts to each step or stage of the research processes (Sekaran 2010). These aspects were carefully considered when we were conducting the current study.

Knowledge sharing also plays a significant role in ethical considerations of a research, meaning that those who participated in the study should be given a chance to share in the knowledge gotten from their data and the conclusion reached. This can also lead to more application of a study's conclusions. Thus, we will share the study findings with all interested parties/persons in Lebanon and abroad.

Importantly, disclosing identities or any information of the participants could be unethical. Participants were told that the information collected will not be disclosed and that the whole instrument did not have anything related to the identity of participants.

Finally, there was absolutely no falsification or distortion in reporting the data collected during the study (Sekaran, 2000). This study was conducted considering ethical responsibility in lieu with the principles of research ethics stated by Ticehurst and Veal (1999) as cited in Kripanont (2007). That is, that no harm must occur to the subjects of the study, subjects should take part freely, and based on informed consent. All of these principles were considered and adhered to in this study as discussed above.

#### *4.9 SUMMARY*

This chapter explained the composition of research tool and population sample used in this study. Designating the modes of data analysis was another highlight of the study. The way we see it, we want this study to be as balanced and neutral as possible. Hence, without deflating the welfares of this methodology we mention both the strengths and weaknesses of the study. In light of the weaknesses of the methodology and diversity in ways of carrying out research, we also brings into focus the alternative research techniques that can be followed by any researcher who wants to graft on a similar topic.

The following chapter will analyze the research findings and will debate them in light of the our observation and theoretical evidence.



# CHAPTER FIVE

## Results and analysis of the application to Beirut





# CHAPTER FIVE: RESULTS AND ANALYSIS OF THE APPLICATION TO BEIRUT

## *5.1 INTRODUCTION*

The previous chapter aimed at highlighting the research purpose and presenting scholarly perspective on the topic and methodology. It gave a clear perspective on the research model and where the research was heading. It is necessary to do that to achieve research aims and objectives of this study. The last chapter provided a detailed insight on defining the philosophy of research, data collection, sampling and analysis techniques. The main purpose of doing so was to enlighten the readers on the understanding of the topic, so moving forward when they read this chapter, they can understand the analysis of transportation choices supported by data findings. This chapter will present the analysis of the data collected and will explain the factors that affect the choice of mode of transportation for the people of Beirut. This chapter will present the results in a comprehensive and meaningful way to set them in line with the objectives of the study.

## *5.2 RESEARCH FRAMEWORK*

It is necessary to conduct a research with having proper structure and theme identified. Hence, researcher elected for a thematic analysis for the research. Boeije (2010) has stated thematic analysis as a source to find various themes for the study that can assist researcher in analyzing the data and reader in understanding it. According to the author, thematic analysis determines a way to find other themes that help explaining the primary themes in a more solid manner. As practically exemplified by Bryman and Burgess (2004) and Ozuem et al (2008), such a framework empowers the researcher to reconsider and rework on huge quantity of data more efficiently and effectively.

Keeping the significant importance of thematic analysis, the researcher has analyzed data using the thematic analytical framework. The logic of reliance on this method comes from logical arguments given by various scholars. As suggested by Bryman and Burgess (2004), this technique is more disciplined and necessary for detecting, defining, explaining and exploring problems that form the basis for the research. Moreover, it gives the study a broader and clearer picture to assess all the data without ignoring important information (Tuckett 2005).

It is an established fact, now that research gives data that is amicably diverse; hence, identifying the various topics to develop a logical analogy is important. Though, the research tool of questionnaire- is close ended in this study but considering the fact that respondent are from different regions and have different demographics and that any research tool is not perfect enough to cater all these intangible factors.

Since the researcher is not building theories and is rather testing hypothesis, thus having a more rational perspective is more critical in this kind of study that can sift, chart, sort and explain data as they relay to important issues and themes being discussed during the data collection process that has

been adopted (Tuckett 2005). The researcher has applied non-parametric and parametric techniques together to identify relationships between variables. This makes the findings of the research strong enough to backup the notion of mode of transportation choices in Beirut.

### 5.3 TESTS APPLIED

To draw a meaningful quantitative analysis, researcher had the choice to apply various tests in the study. However, researcher wanted it to be comprehensive and be able to draw meaningful results out of it. Non-parametric tests have been applied in this study. For non-parametric tests, multiple categories have been used as per the questionnaire.

Multinomial Logistics Regression Analysis (MLR) has been done to test the hypothesis of the study. The data and the sample size gave the researcher the liberty to apply MLR.

In order to understand MLR, it is first necessary to build up knowledge of reader on logistics regression and then move forward.

#### 5.3.1 LOGISTICS REGRESSION

There are two categories of logistics regression:

- Binary or Logit Regression: It is applied when the number of categories of Independent variables is equal to 2.
- Multinomial regression: It is applied when the number of categories of independent variables is more than 2.

Equation 1:

$$\text{log-likelihood} = \sum_{i=1}^N [Y_i \ln P_{Y_i} + (1 - Y_i) \ln(1 - P_{Y_i})]$$

The log-likelihood is based on summing the probabilities associated with the predicted and actual outcomes. The log-likelihood statistic is analogous to the residual sum of squares in multiple regressions in the sense that it is an indicator of how much unexplained information there is after the model has been fitted. It follows that large values of the log-likelihood statistic indicate poorly fitted statistical models, because the large the value of log-likelihood, the more unexplained observations there are.

##### 5.3.1.1 Odd Ratio (Exp (B))

Exp (B) represents the ratio-change in the odds of the event of interest for a one-unit change in the predictor. If the value is greater than 1, then as the predictor increases, the odds of the outcome occurring increase. Conversely, a value less than 1 indicates that as the predictor increases, the odds of the outcome occurring decrease.

### 5.3.1.2 -2 Log Likelihood

The log-likelihood is based on summing the probabilities associated with the predicted and actual outcomes (Tabachnick & Fidell, 2012). The log-likelihood statistic is analogous to the residual sum of squares in multiple regressions in the sense that it is an indicator of how much unexplained information there is after the model has been fitted.

It follows; therefore, that large values of the log-likelihood statistic indicate poorly fitted statistical models, because the larger the value of the log-likelihood, the more unexplained observations there are.

### 5.3.1.3 R-Square

The following methods are used to estimate the coefficient of determination:

- Cox and Snell's R<sup>2</sup> (Cox and Snell, 1989)
- Nagelkerke's R<sup>2</sup> (Nagerkerke, 1991): Negerkerke's R<sup>2</sup> is an adjusted version of the Cox and Snell R-Square that adjusts the scale of the statistic to cover the full range from 0 to 1.
- McFadden's R<sup>2</sup> (McFadden, 1974)

## 5.3.2 MULTINOMINAL LOGISTIC REGRESSION

Multinomial logistic regression is employed in research when the dependent variable is nominal or categorical. In the survey data it is employed when responses of the questions are recorded into a set of categories which cannot be ordered in any meaningful way, particularly when there are more than two categories. Multinomial logistic regression is a solution to the classification problem that assumes that a linear combination of the observed features and some problem-specific parameters can be used to determine the probability of each particular outcome of the dependent variable.

This study tests five different hypothesis using the multinomial econometric methods. The first includes Car as a driver(q9a) as dependent variable with four different options of response from the respondents. These options of response include „a few times a year“; „a few times a month“; „a few times a week“; and „daily“.

The second includes “**Car as a passenger(q9b)**” as the dependent variable with the same four options of response as in the first model.

The third and the fourth include “**Bus(q9d)**” and “**Service (shared taxi-q9l)**”, respectively as the dependent variables with the same options as mentioned earlier.

The fifth includes “**Mode of transport between work/school place and residence-q21**”, as the dependent variable with the options of response such as “Others”; “car drive”; “bus”; “corporate/school transport”; “on foot” and “shared taxi/cab”.

There are two categorical independent variables employed in each of the five hypotheses. Occupation is the way of earning of income. It can be done by working in lower class as “worker”; working in a white collar community with a middle class status as “employee”; running your own entrepreneurship as “self-employed” and being out of work as “unemployed”. Similarly, status in management can be your position in the hierarchy of the organization you are working for. This can include” Senior executive” being at the top, “Middle management” being second or third tier in the hierarchy; “office

worker” being the lowest and “others” being in an organization where hierarchy is not defined. The variables included in the study “What is your main occupation? (q12)” are “unemployed”; “worker”; “employee” and “self-employed”] and “Status in Management-q13” are “others”; “senior executive”; “middle management”; “office worker”]. Results of these five models are categorized into five sets of tables such as Model 1, Model 2, Model 3, Model 4 and Model 5.

**Objective:** is to see the effect of being in various occupations on the probability of using car as driver in various time span situation, that is, a few times a year, a few times a month, a few times a week, Daily in the first model and other models pursue their objectives as per categories of the variables.

### 5.3.2.1 MODEL FITTING INFORMATION TABLE

There is a “Model Fitting information Table” in all the result. This table in each case is with inclusion of all (Independent variables) IVs whereas Null Model is with Intercept only. ***H<sub>0</sub>: There is no difference in the two models. Rejection of this null hypothesis means the full model is good and IVs are significant.*** Significance at 5% or less supports the model tested with multinomial regression options. All the variables play an important role in the determination of the Dependent Variables (DV). In all the five models, the log likelihood ratio falls significantly which shows marvellous contribution of IVs in the explanation of variation of the DV. Decrease in the loglikelihood ratio proves significant decline in the residual sum of squares which is one of characteristics of a good model.

#### 5.3.2.1.1 GOODNESS OF FIT TABLE

The results presented in the tables are based on Chi-squared distribution. The most appropriate statistic is the „Pearson“ for which the null hypothesis runs as ***H<sub>0</sub>: The Model is adequately fit.*** Acceptance of this null hypothesis proves adequately fitness of the model. In all the five models tested in this study the null hypothesis for goodness of fit is accepted

#### 5.3.2.1.2 PSEUDO R<sup>2</sup>

The value of all the pseudo R<sup>2</sup> are similar to the conventional R<sup>2</sup> though not the same as in the case simple regression models. For example, Cox and Snell, Nagelkerke and McFadden are 44.4%, 48.7% and 24.3% respectively, indicating 44.4%, 48.7% and 24.3% variation in the dependent variable is explained by the independent variable included in the model. Generally, the last two R<sup>2</sup> are the better options than the Cox and Snell in case of multinomial regression models.

#### 5.3.2.1.3 LIKELIHOOD RATIO TEST TABLE

Results presented in this table show significance of each variable in the model. At each step, when the IV is added to the variable, the significance of the model improves indicating significant effect of IVs on DV.

#### 5.3.2.1.4 PARAMETER ESTIMATION TABLE

Comparison is with the reference category (which is omitted by the system while estimating coefficients of the variables. It must be significant to show as to how far one category is different from the reference category. If coefficient of any

category of an IV is not significant, that shows its effect on the DV which is not different from the reference category.

#### 5.3.2.1.5 CLASSIFICATION TABLE

Overall should be with a greater proportion for the model to be appropriate. If the overall percent is less than 50%, the findings recommend researcher to add more IVs in the model. In all the 5 models this ratio is more than 50%.

According to Field (2013), the following should be kept in mind related to Logistic regression:

- We predict the probability of favorable options of DV based on IVs
- McFadden's  $R^2$  is used in case of Multinomial Models.
- Cox value is never 1 even if the fit is perfect.
- Iteration History Table shows how log likelihood ratio is reduced in various steps.
- Omnibus Test (Chi-squared test) of the model should show significance of each IV included in the model to reject  $H_0$ : IV does play any role in predicting DV's Probab.
- Hosmer and Lemeshow Test:  $H_0$ : There is no significant difference between observed and the expected value (For the best model accept  $H_0$ ).
- Classification table shows the proportion of correct prediction (out of actual Y values) which should be  $> 50\%$  cut off point.
- Wald values are actually  $t^2$ .
- Variables in the Equation /table: Exp(beta) value shows the number of chances increase or decrease as a result of increase in the value of IV of beta.
- In case of multicollinearity use the option of Forward Wald to automatically get correct results by creating table of „Variable Not in the Equation“ for the unimportant IV.

### 5.4 CROSS TABULATION OF INTENTIONS

Cross tabulations are simply data tables that give the findings of the entire group of respondents as well as results from sub-groups of survey respondents. Cross tabulations allow the researcher to examine relationships within the data that might not be readily visible when analyzing total survey responses.

The results offered in the Cross tabulation relate two variables; one is shown in the rows and the other is in the columns. If we observe the increasing and decreasing trend along each row, we can see whether the relationship of variables is negative or positive. Looking at the increasing and decreasing trend along each row we can understand whether the relationship of variables is positive or negative. In a multiple response analysis, it is easier to create cross tabulation tables for statements representing main category or group. This scheme helps to depict all the responses to a group. The results of cross tabulation provide concise information about the group variables. In the frequency tables, column representing different response show the possible response to each option listen in the questionnaire against each question. The percent column analyzes the percentage of total responses represented by each given option. This could not be easily achieved from individual frequency tables.

## 5.5 NON PARAMETRIC MEASURES OF ASSOCIATION

The non parametric tests are generally preferred when the sample size is small or there are qualitative variables. Data for the present study has been collected through survey and it is cross sectional in nature. Most of the variables are measured on likert scale because of which parametric tests are not suitable for this data set. The parametric test e.g. OLS, GLS and other methods require very rigid assumptions to be accomplished in order to perform the test (Corder and Foreman, 2009). The data collected by survey is generally not normally distributed in nature because of which it cannot be spread over the bell-shaped normal curve.

There is long list of non-parametric test but the present study considers only three of the following non-parametric tests:

1. Phi-coefficient
2. Cramer's V
3. Somers'

d

The Chi square test has certain limitations because of which it has not been employed directly. Rather, the chi-square based test has been employed which overcome the shortcomings of the original chi-square test (Kendall, Stuart and Arnold, 1999).

### 5.5.1 LIMITATIONS OF CHI-SQUARE TESTS

1. It gives scarce information about the potency and type of association between the variables. Furthermore, it computes the association of the independent variables only.
2. It doesn't discuss how two or more variables are related.
3. Certain types of variables may calculate in the same value of the chi-square statistic.

### 5.5.2 PHI-COEFFICIENT

Phi-Coefficient is a suitable measure than ordinary chi-square because the value of phi is amended for redundant increase in the number of rows and the columns. Furthermore, if there is increase in the sample size, the Phi-coefficient does not significantly increase.

$$\phi = \sqrt{\frac{\chi^2}{N}}$$

Where a good measure is  $0 \leq \phi \leq 1$

### 5.5.3 CRAMER'S V

It is generally used when both variables are nominal.

$$V = \sqrt{\frac{\chi^2}{N(k-1)}}$$

Cramer's V is believed as further enhancement in the measurement of relationship of variables. The value of Cramer V depicts potency of relationship between the variables. Addition of the term „k“ further improves its counterfeit values. In the formula, „k“ is the number of rows or the number of columns whichever is less. It determines association of variables. Its range is between 0 and 1. It is considered to be a high level of Phi test.

#### 5.5.4 SOMER'S D

Gamma tau-b, tau-c are symmetric measures of relationship between the variables. The value of these statistics is more or less identical irrespective of classification of dependent or independent variables. Somer's d is dissimilar from Gamma in the way that Gamma excludes tied cases, whereas Somer's d includes tied cases. That is why while calculating Somer's d, dependent variable should be clearly definite. Somer's d D determines the direction of association, whether it is positive or negative.

In Cross tabs, should we rely on Phi-Coefficient or Cramer's V. This can be determined by following:

- If it is a 3 by 3 table, then we should rely on Cramer's V.
- However, if it is a 2 by 2 table, then we should rely on Phi-Coefficient. Phi Value can be more than 1.

Somer's D determines the direction of association. -1 means perfectly negative relationship and +1 means perfectly positive relationship. 0 means no relationship. Usually the association measure lies somewhere between 0 and 1.

## 5.6 CROSS TABULATIONS

### 5.6.1 USING CAR AS A DRIVER IN RELATION TO GENDER AND OCCUPATION

The results presented in table CT1 relate gender and the main occupation of the head of the family with using car as a driver. The main occupation includes worker (lowest rank) , employee and self employed (Highest rank).



Table CT 1: Using car as a driver in relation to Gender and Occupation

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	.396	.033	11.441	.000
			Car as a driver(q9a) Dependent	.423	.035	11.441	.000
			What is your main occupation?(q12) Dependent	.372	.033	11.441	.000
Female	Ordinal Ordinal	bySomers' d	Symmetric	.427	.038	10.317	.000
			Car as a driver(q9a) Dependent	.419	.038	10.317	.000
			What is your main occupation?(q12) Dependent	.434	.041	10.317	.000
Total	Ordinal Ordinal	bySomers' d	Symmetric	.477	.023	21.512	.000
			Car as a driver(q9a) Dependent	.476	.022	21.512	.000
			What is your main occupation?(q12) Dependent	.478	.023	21.512	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

## Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.512	.000
		Cramer's V	.295	.000
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.644	.000
		Cramer's V	.372	.000
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.608	.000
		Cramer's V	.351	.000
	N of Valid Cases		1038	

The results presented in CT1 reveal that Somer's D is 0.00, which is the probability of Type I Error. When the value of asymmetric variable is extremely low, we reject the null hypothesis. This means there is a strong relationship between the variables. We can also observe that it is significant for both male and female.

Somer's D takes each variable as dependent and calculates it according to that. In case of Male gender taking car as a driver, Somer's D is higher (0.423) than female (0.419). This means that men are using car as a driver more than women. Statistical theory supports either relationship.

If we look at the Phi and Cramer's V table, they are both significant as well even though, even though the measure of Phi and Cramer's V is greater than Somer's D. We can generalize that this relationship exists by statistical theory, not by chance. The case of female is stronger.

If we present the relationship in a theoretical form, we can see that occupation plays a significant role in using car as a driver. This means that if you are working and if your job gives you more autonomy, there is a significant chance that you will be owning a vehicle of your own and then using it as a main mode of transportation. However, the lower your rank in autonomy, the least likely it is for you to own a vehicle. This percentage gets more for female, female's chance of owning a vehicle is higher with employment. Even though the Cramer's V is very low but still it signifies that a relationship exists.

### 5.6.2 USING CAR AS A DRIVER TO GENDER AND STATUS IN OCCUPATION

In the previous section, we saw that those who are working whether for an organization or in their own business, are trended towards owning a vehicle. This section compares how the status in your occupation differs the previous trend. Status in management includes Senior Executive, Middle Management, Office worker or others. The relationship in this case is also significant as we can see that the level is 0.00. However, the level of Somer's D is lesser than it was in being employed. This shows that being employed itself plays a higher role than the rank in the organization. The relationship exists in using your car as a driver to the status. We can see that Cramer's V and Phi are much higher for females than for males. We can depict from this set that in females, if you have a higher status in management, you are more likely to use your car as a driver, but in males if your status in management is higher, you are less likely to use your car as a driver. This can also be related to the fact that when your status is higher in management, you generally have a driver and you use the car as a passenger and not as a driver. This could be the trend in Beirut in case of status in management. This also shows that women display more independence when it comes to professional ranking. The higher the rank, the more likely they will use their car as a driver

CT2- Using Car as a driver to gender and status in occupation

Gender of Head of Family(q8e)			Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal by Ordinal Somers' d	Symmetric	.216	.033	6.298	.000
		Car as a driver(q9a) Dependent	.297	.045	6.298	.000
		Status in Management-q13 Dependent	.169	.027	6.298	.000
Female	Ordinal by Ordinal Somers' d	Symmetric	.177	.053	3.371	.001
		Car as a driver(q9a) Dependent	.168	.051	3.371	.001
		Status in Management-q13 Dependent	.186	.055	3.371	.001
Total	Ordinal by Ordinal Somers' d	Symmetric	.291	.026	11.534	.000
		Car as a driver(q9a) Dependent	.327	.029	11.534	.000
		Status in Management-q13 Dependent	.262	.023	11.534	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.362	.000
		Cramer's V	.209	.000
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.703	.000
		Cramer's V	.406	.000
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.606	.000
		Cramer's V	.350	.000
	N of Valid Cases		1038	

### 5.6.3 USING CAR AS A DRIVER IN RELATION TO GENDER AND TYPE OF PROFESSION

In table CT3, the relationship between type of profession and gender to the use of car as a driver is predicted. Type of profession includes farmer, Entrepreneur with less than 5 employees, Entrepreneur with more than 5 employees, Doctors/lawyers/ experts and others. We can see that there exists a relationship between type of profession and using car as a driver. We can see that the type of profession gets better in rank. This means that if we look at the direction of measures of association in Somer's D, in male the better your profession gets, the less likely you are to use your car as a driver. However, we can also see that it is rejected in case of females. This is in relationship to our result in previous section. This means that the more professional women become, the more likely they will use car as a driver. Type of profession is independent of their choice of usage. Weak Phi-Coefficient and Cramer's V also signifies the same trend. However, in case of men the relationship exists but it is weak. This means that the better your profession gets, the less likely you are to use your car as your driver. It can also be contributed to the fact that the distance between places of better employment and better living communities is higher in Beirut. So if you have a better job, you are more likely to be living farther in the city, which increases the driver to your workplace. Considering the traffic hustle in Beirut, people might prefer getting a driver to save the driving hassle as they get better jobs.

CT3- Using Car as a driver in relation to gender and type of profession

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	.183	.029	5.210	.000
			Car as a driver(q9a) Dependent	.471	.070	5.210	.000
			Type of Profession-q14 Dependent	.114	.022	5.210	.000
Female	Ordinal Ordinal	bySomers' d	Symmetric	.102	.035	2.827	.005
			Car as a driver(q9a) Dependent	.163	.056	2.827	.005
			Type of Profession-q14 Dependent	.074	.026	2.827	.005
Total	Ordinal Ordinal	bySomers' d	Symmetric	.176	.020	7.505	.000
			Car as a driver(q9a) Dependent	.385	.042	7.505	.000
			Type of Profession-q14 Dependent	.114	.015	7.505	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

## Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.284	.000
		Cramer's V	.201	.000
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.231	.001
		Cramer's V	.163	.001
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.254	.000
		Cramer's V	.180	.000
	N of Valid Cases		1038	

### 5.6.4 USING CAR AS A PASSENGER TO GENDER AND STATUS IN MANAGEMENT

The results in the earlier sections predicted that there is a positive relationship between using car as a driver to type of profession, status in management and employment. In order to verify the results of the previous section, we run the relationship of using car as a passenger to the status in management to see if they give the same result as we predicted from the previous relationship. As we can see in table CT4 that the Somer's D is negative. We mentioned earlier that somer's D predicts the direction of association of the variables. So a positive value shows a positive relationship and a negative value shows that there is a negative relationship between the variables. As we can see that in males the relationship is negative. If we refer to the status in management, a higher number predicts a smaller rank. So the sequence of status was Senior Executive, Middle Management, Office worker and others. So the higher the job is, the more likely you will use car as a passenger. So the likelihood of occurrence is in negative in relation to the ranks of management. The relationship in case of female is positive, even though it is very weak as predicted from the significance level. This means women's status in management doesn't play a role in their choice of using car as a driver or a passenger. This was predicted from earlier results as well.

CT-4: Using Car as a Passenger to Gender and Status in Management

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal	bySomers' d	Symmetric	-.189	.030	-6.057	.000
	Ordinal		Car as passenger(q9b) Dependent	-.292	.045	-6.057	.000
			Status in Management-q13 Dependent	-.140	.023	-6.057	.000
Female	Ordinal	bySomers' d	Symmetric	.115	.052	2.231	.026
	Ordinal		Car as passenger(q9b) Dependent	.113	.050	2.231	.026
			Status in Management-q13 Dependent	.117	.053	2.231	.026
Total	Ordinal	bySomers' d	Symmetric	-.142	.026	-5.316	.000
	Ordinal		Car as passenger(q9b) Dependent	-.166	.031	-5.316	.000
			Status in Management-q13 Dependent	-.123	.023	-5.316	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.261	.000
		Cramer's V	.150	.000
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.482	.000
		Cramer's V	.278	.000
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.443	.000
		Cramer's V	.255	.000
	N of Valid Cases		1038	

### 5.6.5 USING BUS IN RELATION TO GENDER AND TYPE OF PROFESSION

In order to understand the attitude of people to use public transport, it is necessary to understand the demographics of the population. In table CT-5, we can see that there is an insignificant relationship of male's occupation to the bus usage. It can be implied by the finding that occupation plays no role in use of bus in case of males. However, in case of females, occupation does play a role as the relationship is significant. But as we can see that Somer's D is negative which signifies that even though the relationship exists, but it is negative. We can understand that as the type of profession ranks gets higher in our data, there is more autonomy and likelihood of more money as well. So, the better the profession, the less likelihood of a female using bus in the city of Beirut.



CT-5: Using Bus in relation to gender and type of profession

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	.045	.035	1.291	.197
			Bus(q9d) Dependent	.034	.026	1.291	.197
			What is your main occupation?(q12) Dependent	.065	.050	1.291	.197
Female	Ordinal Ordinal	bySomers' d	Symmetric	-.358	.038	-8.140	.000
			Bus(q9d) Dependent	-.290	.035	-8.140	.000
			What is your main occupation?(q12) Dependent	-.466	.048	-8.140	.000
Total	Ordinal Ordinal	bySomers' d	Symmetric	-.045	.023	-1.946	.052
			Bus(q9d) Dependent	-.034	.017	-1.946	.052
			What is your main occupation?(q12) Dependent	-.070	.036	-1.946	.052

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.284	.000
		Cramer's V	.164	.000
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.662	.000
		Cramer's V	.382	.000
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.479	.000
		Cramer's V	.276	.000
	N of Valid Cases		1038	

#### 5.6.6 USING BUS IN RELATION TO GENDER AND TYPE OF PROFESSION

The results presented in CT-6 shows that there is no relationship between using bus to type of profession in males. We can see that in the significance level. However, in case of females, there is a relationship but a negative relationship exists. Phi and Cramer's V say that there is no relationship in case of females too. We can infer from these results that bus usage has nothing to do with the type of profession of any person. We can also say that bus usage is not common in Beirut at all.

CT-6: Using Bus in relation to gender and type of profession

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	.010	.040	.249	.803
			Bus(q9d) Dependent	.014	.057	.249	.803
			Type of Profession-q14 Dependent	.008	.030	.249	.803
Female	Ordinal Ordinal	bySomers' d	Symmetric	-.177	.025	-5.693	.000
			Bus(q9d) Dependent	-.214	.032	-5.693	.000
			Type of Profession-q14 Dependent	-.150	.024	-5.693	.000
Total	Ordinal Ordinal	bySomers' d	Symmetric	-.073	.024	-2.988	.003
			Bus(q9d) Dependent	-.096	.031	-2.988	.003
			Type of Profession-q14 Dependent	-.059	.019	-2.988	.003

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.181	.002
		Cramer's V	.128	.002
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.203	.010
		Cramer's V	.143	.010
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.121	.020
		Cramer's V	.085	.020
	N of Valid Cases		1038	

#### 5.6.7 USING MOTORCYCLE TO GENDER AND STATUS IN MANAGEMENT

As a whole, we can see that even though the relationship is significant being very weak in case of females. But the direction of the measure of association is negative as we can see from Somer's D. In cases of both male and female, the smaller the rank (Senior Executive) in data set, the less likely it is that the person will use motorcycle. According to Phi and Cramer's V, in case of females, the likelihood is stronger than males. This can also predict that usage of motorcycles by females is negligible in Beirut.

CT-7: Using Motorcycle to gender and status in management

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	-.131	.032	-3.921	.000
			Motorcycle(q9g) Dependent	-.146	.036	-3.921	.000
			Status in Management- q13 Dependent	-.118	.030	-3.921	.000
Female	Ordinal Ordinal	bySomers' d	Symmetric	-.144	.048	-2.922	.003
			Motorcycle(q9g) Dependent	-.105	.036	-2.922	.003
			Status in Management- q13 Dependent	-.231	.076	-2.922	.003
Total	Ordinal Ordinal	bySomers' d	Symmetric	-.182	.026	-6.883	.000
			Motorcycle(q9g) Dependent	-.157	.023	-6.883	.000
			Status in Management- q13 Dependent	-.216	.030	-6.883	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.199	.003
		Cramer's V	.115	.003
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.452	.000
		Cramer's V	.261	.000
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.287	.000
		Cramer's V	.165	.000
	N of Valid Cases		1038	

### 5.6.8 USING MOTORCYCLE IN RELATION TO GENDER AND TYPE OF PROFESSION

It can be seen from the table CT-8 that the relationship between using motorcycles and type of profession is insignificant in females. However, it is significant in males but the measure of association is negative. This means that as per our data, as we go up the profession (highest being expert), the probability of using motorcycle would decline. Cramer's V and Phi-Coefficient also support the similar results.

CT-8: Using Motorcycle in relation to gender and type of profession

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	-.103	.024	-3.926	.000
			Motorcycle(q9g) Dependent	-.202	.045	-3.926	.000
			Type of Profession-q14 Dependent	-.069	.017	-3.926	.000
Female	Ordinal Ordinal	bySomers' d	Symmetric	-.052	.040	-1.262	.207
			Motorcycle(q9g) Dependent	-.054	.042	-1.262	.207
			Type of Profession-q14 Dependent	-.049	.039	-1.262	.207
Total	Ordinal Ordinal	bySomers' d	Symmetric	-.098	.021	-4.403	.000
			Motorcycle(q9g) Dependent	-.145	.031	-4.403	.000
			Type of Profession-q14 Dependent	-.074	.016	-4.403	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.144	.045
		Cramer's V	.102	.045
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.130	.323
		Cramer's V	.092	.323
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.135	.004
		Cramer's V	.095	.004
	N of Valid Cases		1038	

### 5.6.9 USING BICYCLES IN RELATION TO GENDER AND STATUS IN MANAGEMENT

The attitude of using bicycles is quite less in Beirut. As we experienced from our frequency table FT-1 that the highest percentage are those who use it a few times a year (88.6%) and the smallest percentage are those who use a bicycle on a daily basis (0.8%). So we can infer that since the attitude of using bicycles is already less, so any dependent variable would not make a significant impact.



*5.6.10 FT-1: USING BICYCLES IN RELATION TO GENDER AND STATUS IN MANAGEMENT*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A few times a year	920	88.6	88.6	88.6
	A few times a month	82	7.9	7.9	96.5
	A few times a week	28	2.7	2.7	99.2
	Daily	8	.8	.8	100.0
	Total	1038	100.0	100.0	

We can see from table CT-9 that there is a relationship between bicycle usage and status in management in male, however, there doesn't exist a relationship in case of females. The direction of the measures of association as depicted through Somer's D is negative in case of males. The results projected in Phi-Coefficient and Cramer's V are also in agreement with the previous results.

CT-9: Using Bicycles in relation to gender and status in management

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	-.212	.018	-8.570	.000
			Bicycle (all kinds-q9h) Dependent	-.201	.021	-8.570	.000
			Status in Management-q13 Dependent	-.224	.022	-8.570	.000
Female	Ordinal Ordinal	bySomers' d	Symmetric	.025	.009	1.424	.154
			Bicycle (all kinds-q9h) Dependent	.013	.009	1.424	.154
			Status in Management-q13 Dependent	.844	.018	1.424	.154
Total	Ordinal Ordinal	bySomers' d	Symmetric	-.196	.015	-9.527	.000
			Bicycle (all kinds-q9h) Dependent	-.136	.014	-9.527	.000
			Status in Management-q13 Dependent	-.350	.026	-9.527	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.226	.000
		Cramer's V	.130	.000
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.160	.015
		Cramer's V	.160	.015
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.246	.000
		Cramer's V	.142	.000
	N of Valid Cases		1038	

#### 5.6.11 USING BICYCLES IN RELATION TO GENDER AND TYPE OF PROFESSION

In order to verify the results that have been presented in section 5.11.9, it is necessary that we run the same tests with a different dependent variable. As we can see from Table CT-10, that the relationship between type of profession and bicycle usage in case of males exists however, it's insignificant in case of females. Moreover, we saw that the relationship is also negative as depicted by Somer's D. We can also see that in case of Phi-Coefficient and Cramer's V, the relationship doesn't exist in both cases.

**5.6.12 CT-10: USING BICYCLES IN RELATION TO GENDER AND TYPE OF PROFESSION**

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	-.127	.010	-6.707	.000
			Bicycle (all kinds-q9h) Dependent	-.198	.016	-6.707	.000
			Type of Profession-q14 Dependent	-.093	.013	-6.707	.000
Female	Ordinal Ordinal	bySomers' d	Symmetric	-.011	.004	-1.405	.160
			Bicycle (all kinds-q9h) Dependent	-.006	.004	-1.405	.160
			Type of Profession-q14 Dependent	-.151	.018	-1.405	.160
Total	Ordinal Ordinal	bySomers' d	Symmetric	-.121	.008	-8.591	.000
			Bicycle (all kinds-q9h) Dependent	-.125	.011	-8.591	.000
			Type of Profession-q14 Dependent	-.118	.010	-8.591	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

### Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.141	.054
		Cramer's V	.099	.054
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.029	.837
		Cramer's V	.029	.837
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.125	.013
		Cramer's V	.088	.013
	N of Valid Cases		1038	

### 5.6.13 USING TAXI IN RELATION TO GENDER AND OCCUPATION

There is a need to understand the usage of each type of transport to see how profession and gender affects the usage. Taxi usage in Beirut is still not very common. As we can see from table FT-2 that there is a huge amount of people who use it only a few times a year (94.2). The lack of comfort and convenience can be accounted for the usage. Moreover, availability and fare also play a significant role. Also, ever since Uber and Careem have started their operations in Beirut, the usage of taxi has fallen significantly.

FT-2: Using Taxi in relation to gender and occupation

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid A few times a year	978	94.2	94.2	94.2
A few times a month	37	3.6	3.6	97.8
A few times a week	21	2.0	2.0	99.8
Daily	2	.2	.2	100.0
Total	1038	100.0	100.0	

We can see from Table CT-11 that there is no relationship between taxi usage in males with their profession. However, there exists a relationship in case of females, being very weak. We can infer from this that females are still using taxis, and men, not matter which profession are most likely not the riders in taxis.

CT-11: Using Taxi in relation to gender and occupation

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	.013	.033	.386	.699
			Taxi(q9i) Dependent	.008	.020	.386	.699
			What is your main occupation?(q12) Dependent	.036	.093	.386	.699
Female	Ordinal Ordinal	bySomers' d	Symmetric	.186	.031	4.144	.000
			Taxi(q9i) Dependent	.108	.026	4.144	.000
			What is your main occupation?(q12) Dependent	.666	.090	4.144	.000
Total	Ordinal Ordinal	bySomers' d	Symmetric	.054	.025	2.052	.040
			Taxi(q9i) Dependent	.031	.015	2.052	.040
			What is your main occupation?(q12) Dependent	.189	.090	2.052	.040

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.196	.004
		Cramer's V	.113	.004
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.403	.000
		Cramer's V	.285	.000
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.287	.000
		Cramer's V	.166	.000
	N of Valid Cases		1038	

5.6.14 USING AUTOCAR IN RELATION TO GENDER AND TYPE OF PROFESSION

We can see from table CT-12 that type of profession has a relationship between autocar usage. However, the relationship is negative as predicted by Somer's D. In case of females, the relationship is very weak, but still exists and is negative as well. The result is insignificant in case of Phi-Coefficient and Cramer's V for females.



CT-12: Using Autocar in relation to gender and type of profession

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal Ordinal	bySomers' d	Symmetric	-.142	.011	-6.907	.000
			Autocar(q9j) Dependent	-.232	.017	-6.907	.000
			Type of Profession-q14 Dependent	-.102	.014	-6.907	.000
Female	Ordinal Ordinal	bySomers' d	Symmetric	-.047	.008	-3.065	.002
			Autocar(q9j) Dependent	-.028	.009	-3.065	.002
			Type of Profession-q14 Dependent	-.154	.018	-3.065	.002
Total	Ordinal Ordinal	bySomers' d	Symmetric	-.138	.008	-9.158	.000
			Autocar(q9j) Dependent	-.154	.012	-9.158	.000
			Type of Profession-q14 Dependent	-.126	.011	-9.158	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.155	.001
		Cramer's V	.155	.001
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.066	.403
		Cramer's V	.066	.403
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.141	.000
		Cramer's V	.141	.000
	N of Valid Cases		1038	

### 5.6.15 USING SHARED TAXI IN RELATION TO GENDER AND STATUS IN MANAGEMENT

Even though shared taxi usage is a growing trend in the rest of the world but in Beirut, it is still not a very popular choice for most of the people. We can see from table CT-13 that there is no relationship between status in management in both genders to the usage of shared taxi. This could be directed to the lack of safety in public transport and also the conservative system of society because of which people don't prefer using shared taxi.

CT-13: Using Shared taxi in relation to gender and status in management

Gender of Head of Family(q8e)				Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Male	Ordinal	bySomers' d	Symmetric	-.055	.035	-1.575	.115
	Ordinal		Service (shared taxi-q9l) Dependent	-.065	.041	-1.575	.115
			Status in Management-q13 Dependent	-.048	.030	-1.575	.115
Female	Ordinal	bySomers' d	Symmetric	-.050	.056	-.890	.373
	Ordinal		Service (shared taxi-q9l) Dependent	-.040	.045	-.890	.373
			Status in Management-q13 Dependent	-.065	.073	-.890	.373
Total	Ordinal	bySomers' d	Symmetric	-.087	.029	-2.937	.003
	Ordinal		Service (shared taxi-q9l) Dependent	-.080	.027	-2.937	.003
			Status in Management-q13 Dependent	-.095	.032	-2.937	.003

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Symmetric Measures

Gender of Head of Family(q8e)			Value	Approx. Sig.
Male	Nominal by Nominal	Phi	.207	.001
		Cramer's V	.120	.001
	N of Valid Cases		626	
Female	Nominal by Nominal	Phi	.597	.000
		Cramer's V	.345	.000
	N of Valid Cases		412	
Total	Nominal by Nominal	Phi	.340	.000
		Cramer's V	.196	.000
	N of Valid Cases		1038	

## 5.7 HYPOTHESIS TESTING

### 5.7.1 HYPOTHESIS 1: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING CAR AS A DRIVER AT DIFFERENT TIME SPAN

In order to understand the results, we first look at the level of significance in Model Fitting Information-I table. We can see that the null hypothesis is rejected. It is a highly significant value which means that statistical theory supports the addition of an independent variable. In short, when you add the independent variable to the model, it makes a difference in the overall effect of the dependent variable, which means there is a relationship between both. From the level of significance, we can see that the relationship between them also exists i.e. there is a relationship between occupation and management status of a person to his usage of car as a driver.

The primary data set is linear i.e. the data is in a sequence structure and if we plot it on a graph, it will form a straight line. We have four options in our dependent variable and independent variable has multiple categories. RSS (Residual Sum of Squares), TSS (Total Sum of Squares) and ESS (Explained Sum of Squares) is calculated on categorical data. The variables in our data are nominal. Log likelihood ratio in table Model Fitting Information-1 portrays if the impact of independent variable is 0 on the dependent variable. According to the table results, by addition of independent variable, the model makes significance difference. The variation of the dependent variable is reduced to 85.736 when you add the independent variable, i.e. it falls significantly from 694.403 to 85.736. Independent variable variation or significant increase in Dependent variable is due to the Independent variable included in the model.

#### Nominal Regression Model 1

##### Model Fitting Information-I

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	694.403			
Final	85.736	608.667	18	.000

For non parametric tests, we have to get results based on Chi-Square. In the table Good-of-Fit-1, we can see that we have Pearson and Deviance based results. According to that, model is adequately fit. For any model to be good, it should be accepted. This model is sufficiently adequate at 2.8%. Deviance however is insignificant at 5.6%. There is a small difference between Pearson and Deviance.

##### Goodness-of-Fit-I

	Chi-Square	df	Sig.

Pearson	14.116	6	.028
Deviance	12.282	6	.056

Since this is a non-linear model estimation, so  $R^2$  is not generated as such. Unit by unit comparison is done. In table Pseudo R-Square-I table, it is called Pseudo because its non-linear estimation. It has its own criteria. There have been three developments in econometrics so far to calculate Pseudo R-Square. They are done through Cox and Snell, Nagelkerke and McFadden. Cox and Snell is not very reliable. If you take all Independent Variables, you won't be able to get  $R^2$ . It increases up to an extent, so there is a chance of the results to mislead. So, for better results, we take the other categories namely Nagelkerke and McFadden. According to Nagelkerke, 48.7% variation in dependent variable can be attributed to Independent variable included in the model. Similarly according to McFadden, 24.3% variation is due to the IVs.

#### Pseudo R-Square-I

Cox and Snell	.444
Nagelkerke	.487
McFadden	.243

Likelihood ratio tests determine the impact of independent variable on the dependent variable. It calculates variable by variable significance. Every independent variable's role or contribution on the dependent variable is calculated. Looking at the results in Table Likelihood Ratio Tests-I, we can see that the impact is increased from 85.736 to 289.038 by the introduction of occupation. Similarly it is increased by 302.092 by the addition of status in management. It clearly tells that when your occupation and your status in management play a role in using a car as a driver in Beirut.

#### Likelihood Ratio Tests-I

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	85.736 <sup>a</sup>	.000	0	.
Ocup	289.038	203.302	9	.000
MgStats	302.092	216.357	9	.000

The chi-square statistic is the difference in  $-2 \log$ -likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

In order to understand the calculations in table Parameter Estimates-I, we need to understand the basics that the system does for generating the results. It considers one unit as a reference category and compares it with the rest. The reference category is generally mentioned in the footnote. In case of table below, it is “Daily”. This means that the system is comparing those who drive car as a driver on a daily basis with all other variables and categories. First, we need to look at the significance value of the table. We can see that the general trend of the table is that most of the values are significant. Exceptions include:

- Middle Management (MgStats=1) using car a few times a year.
- Workers in Occupations (Ocup=1) using car a few times a week.

In order to understand the affect of independent variable on the dependent variable, we look at the Beta values of the table (B). We can see that people in worker class category ( Ocup=1) who use car as a driver few times a year are twice as many as self-employed who use it on a daily basis . This means that lesser people at worker level are using car on a daily basis. Also, we can see that people who are at employed are using the car 17 times lesser (-17.050) than those who are self employed using it on a daily basis.

Similiarly, when we look at the comparisons in the management status, we can see a negative trend in the categories. This means that those in the lowest level of management (MgStats=3) use the car lesser on a daily basis than those in all other levels: Senior Management (approx. 19 times more), middle management (17 times more, refer to table Parameter Estimates-I on page 170) and office worker (approx. 4 times more).

When we look at the comparison of self employed using car on a daily basis to those using few times a month, we see that the trend is negative only for employed people (-15.901). This means that employed people use it 15 times lesser than self employed people’s daily usage. The results are marginally significant when we compare lowest level of management’s daily usage to senior executive’s usage.

Also, we can see that there is a overall negative trend in almost the entire table when we make the comparisons of daily usage with weekly usage across different categories of occupation and management status.

The purpose of Classification-I table is that when we organize independent variables and dependent variables in data, we sat that these are actual values of independent variables. Then we estimate by running regression. Classification table tells the difference of the actual values before and the estimated values after the result. The criteria is having 50% or greater overall percentage explanatory analysis value to consider that independent variables are sufficient. If the values are less than 50%, it means there is a need to add more independent variables to the model. According to the estimates in table Classification-I, we can see that the value is 64.8%. This means that independent variables are playing a significant role on the change in the dependent variable. The diagnostic tests are proving it.

Parameter Estimates-I

Car as a driver(q9a) <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
A few times a year	Intercept	17.395	1.221	202.948	1	.000			
	[Ocup=0]	3.266	.337	93.814	1	.000	26.196	13.529	50.726
	[Ocup=1]	2.637	.409	41.520	1	.000	13.975	6.266	31.169
	[Ocup=2]	-17.050	1.241	188.624	1	.000	3.938E-8	3.456E-9	4.488E-7
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	-19.217	1.216	249.720	1	.000	4.511E-9	4.161E-10	4.891E-8
	[MgStats=1]	-17.474	1196.104	.000	1	.988	2.576E-8	.000	. <sup>c</sup>
	[MgStats=2]	-4.163	.553	56.672	1	.000	.016	.005	.046
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
A few times in a month	Intercept	16.028	1.188	182.009	1	.000			
	[Ocup=0]	1.547	.398	15.100	1	.000	4.700	2.153	10.257
	[Ocup=1]	2.727	.442	38.021	1	.000	15.282	6.424	36.358



	[Ocup=2]	-15.901	1.201	175.390	1	.000	1.243E-7	1.182E-8	1.307E-6
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	-18.115	1.197	229.209	1	.000	1.358E-8	1.301E-9	1.417E-7
	[MgStats=1]	-1.087	.552	3.875	1	.049	.337	.114	.995
	[MgStats=2]	-3.722	.511	53.155	1	.000	.024	.009	.066
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
A few times in a week	Intercept	16.522	.262	3984.013	1	.000			
	[Ocup=0]	.251	.355	.502	1	.478	1.286	.642	2.578
	[Ocup=1]	.166	.533	.097	1	.755	1.181	.415	3.355
	[Ocup=2]	-16.815	.370	2065.922	1	.000	4.980E-8	2.412E-8	1.028E-7
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	-17.915	.000	.	1	.	1.658E-8	1.658E-8	1.658E-8
	[MgStats=1]	-.813	.587	1.920	1	.166	.444	.141	1.401
	[MgStats=2]	-3.302	.523	39.777	1	.000	.037	.013	.103
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.

- a. The reference category is: Daily.
- b. This parameter is set to zero because it is redundant.
- c. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

Classification-I

Observed	Predicted				Percent Correct
	A few times a year	A few times in a month	A few times in a week	Daily	
A few times a year	402	0	0	17	95.9%
A few times in a month	121	0	0	19	0.0%
A few times in a week	55	0	2	27	2.4%
Daily	126	0	0	269	68.1%
Overall Percentage	67.8%	0.0%	0.2%	32.0%	64.8%

5.7.2 HYPOTHESIS 2: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING CAR AS A PASSENGER AT DIFFERENT TIME SPAN

Looking at the level of significance in Model Fitting Information-II table, we can see that the null hypothesis is rejected. It is a highly significant value at 0% which means that statistical theory supports the addition of a independent variable. This means that the addition of independent variable makes an overall difference in the effect of the dependent variable. The relationship between them exists.

Like mentioned earlier, Log likelihood ratio in table Model Fitting Information-II depicts if the overall impact of independent variable is 0 on the dependent variable. We can see that the variation is significant. By the addition of independent variable, the dependent variable is reduced to 99.017. This means that the overall effect is a change of 279.655 times on the estimations.

Nominal Regression Model 2

Model Fitting Information-II

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	378.672			
Final	99.017	279.655	18	.000

The chi-square based results of Pearson and Deviance are presented in Goodness-of-fit-II. We can see that both of the chi-square tests yield insignificant results for the estimations of the model.

Goodness-of-Fit-II

	Chi-Square	df	Sig.
Pearson	9.659	9	.379
Deviance	12.955	9	.165

A unit by unit comparison is presented in the Pseudo-R-Square-II table. We can see from the Nagelkerke and McFadden that 25.4% and 10.2% variation in the model is due to the addition of independent variable. Even though Cox and Snell is not highly recommended but considering the results, 23.6% of the variation in the model is due to the addition of the independent variable.

Pseudo R-Square-II

Cox and Snell	.236
Nagelkerke	.254
McFadden	.102

Likelihood ratio tests determine the impact of independent variable on the dependent variable by calculating variable by variable significance. The results in Table Likelihood Ratio Tests-II tell that the impact is increased from 99.017 to 162.970 by the introduction of occupation. Similarly it is increased from 99.017 to 184.952 by the addition of status in management. It clearly tells that occupation and status in management play a role in using car as a driver in Beirut.

### Likelihood Ratio Tests-II

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	99.017 <sup>a</sup>	.000	0	.
Ocup	162.970	63.953	9	.000
MgStats	184.952	85.935	9	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

The reference category in table Parameter Estimates-II is “Daily”. This means that the system is comparing those who drive car as a passenger on a daily basis with all other variables and categories. First, we need to look at the significance value of the table. We can see that there is a trend of some values being significant and others are not. The ones that are not significant include:

- Workers in Occupations (Ocup=1) using car a few times a year.
- Middle Management (MgStats=1) using car a few times a year.
- Workers in Occupations (Ocup=1) using car a few times a month
- Employees in Occupations (Ocup=2) using car a few times a month.
- Senior Executive (MgStats=0) using car a few times a month
- Middle Management (MgtStats=1) using car a few times a month.
- Workers in Occupations (Ocup=1) using car a few times a week.
- Middle Management (MgStats=1) using car a few times a week.
- Office worker (MgStats=2) using car a few times a week.

We can understand from the above results that the trend of using car as a passenger is overall less in Beirut. The population surveyed for this research are more likely to use car as a driver than as a passenger.

The affect of independent variable on the dependent variable can be seen by looking at the Beta values of the table (B). We can see that people in employment category (Ocup=2) who use car as a passenger few times a year are 14 times as less as self-employed who use it on a daily basis. Also, we can see that people who are in the “Other” occupations category are using the car twice as less as those who are self-employed using it on a daily basis.

Comparing the values in the management status, we can see a negative and positive trend in the categories. This means that those in the lowest level of management (MgStats=3) use the car lesser on a daily basis as a passenger than those who are in the senior management; using it 14 times more likely. The trend for the other two categories of management are similar to the reference category.

When we look at the comparison of self employed using car on a daily basis to those using few times a month, we see that the trend is negative for working class (-1.421). This means that working class use car as a passenger almost 1.4 times less than self employed people’s daily usage. The results in the overall estimates show that the passenger usage of car is quite the same in all categories.

There is a overall negative trend in most of the table when we make the comparisons of daily usage with weekly usage across different categories of occupation and management status.

The Classification-II table tells that the overall percentage of exploratory analysis is not sufficient at 44.3%. We discussed in the previous section that the criteria is 50% or above. This means that the independent variables are not sufficient to cause a significant change in the dependent variable. So there is a need to add more independent variables in order to understand the change.

Parameter Estimates-II

Car as a passenger(q9b) <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
A few times a year	Intercept	16.312	.825	390.909	1	.000			
	[Ocup=0]	-2.049	.450	20.768	1	.000	.129	.053	.311
	[Ocup=1]	-.889	.554	2.572	1	.109	.411	.139	1.218
	[Ocup=2]	-14.646	.884	274.445	1	.000	4.357E-7	7.702E-8	2.464E-6
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	-14.011	.716	383.259	1	.000	8.228E-7	2.024E-7	3.346E-6
	[MgStats=1]	1.031	1.083	.906	1	.341	2.804	.336	23.433
	[MgStats=2]	2.226	1.062	4.393	1	.036	9.266	1.155	74.318
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
A few times a month	Intercept	1.071	847.126	.000	1	.999			

	[Ocup=0]	-1.421	.482	8.695	1	.003	.241	.094	.621
	[Ocup=1]	-.035	.581	.004	1	.951	.965	.309	3.012
	[Ocup=2]	.423	847.126	.000	1	1.000	1.527	.000	. <sup>c</sup>
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	.273	847.126	.000	1	1.000	1.314	.000	. <sup>c</sup>
	[MgStats=1]	-.108	1.167	.009	1	.927	.898	.091	8.839
	[MgStats=2]	3.441	1.058	10.583	1	.001	31.204	3.926	247.993
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
A few times a week	Intercept	16.501	.457	1302.145	1	.000			
	[Ocup=0]	-.949	.476	3.967	1	.046	.387	.152	.985
	[Ocup=1]	-.609	.595	1.047	1	.306	.544	.170	1.746
	[Ocup=2]	-15.573	.579	724.245	1	.000	1.726E-7	5.551E-8	5.364E-7
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	-15.154	.000	.	1	.	2.623E-7	2.623E-7	2.623E-7
	[MgStats=1]	.500	1.158	.186	1	.666	1.648	.170	15.960



[MgStats=2]	1.018	1.127	.816	1	.366	2.767	.304	25.174
[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.

a. The reference category is: Daily.

b. This parameter is set to zero because it is redundant.

c. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

#### Classification-II

Observed	Predicted				Percent Correct
	A few times a year	A few times a month	A few times a week	Daily	
A few times a year	176	49	123	0	50.6%
A few times a month	113	139	87	0	41.0%
A few times a week	76	7	145	0	63.6%
Daily	28	1	94	0	0.0%
Overall Percentage	37.9%	18.9%	43.3%	0.0%	44.3%

### 5.7.3 HYPOTHESIS 3: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING BUS AT DIFFERENT TIME SPANS

The null hypothesis is rejected if we look at the level of significance in Model Fitting Information-III table. It is a highly significant value at 0% which means that statistical theory supports the addition of a independent variable. It elaborates that there is a relationship between the dependent variable and the independent variable.

Like mentioned earlier, Log likelihood ratio in table Model Fitting Information-II depicts if the overall impact of independent variable is 0 on the dependent variable. We can see that the variation is significant. By the addition of independent variable, the dependent variable is reduced to 65.795. This means that a change of 263.185 has occurred due to the addition of independent variable.

#### Nominal Regression Model 3

Model Fitting Information-III

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	328.980			
Final	65.795	263.186	18	.000

The chi-square based results of Pearson and Deviance are presented in Goodness-of-fit-II. We can see that both of the chi-square tests yield insignificant results for the estimations of the model.

Goodness-of-Fit-III

	Chi-Square	df	Sig.
Pearson	10.760	9	.293
Deviance	11.028	9	.274

We can see in the Pseudo-R-Square-III table that the Nagelkerke and McFadden show 30.2% and 18.7% variation in the model is due to the addition of independent variable. Cox and Snell is 22.4% variant in the model is due to the addition of the independent variable.

Pseudo R-Square-III

Cox and Snell	.224
Nagelkerke	.302
McFadden	.187

The results in Table Likelihood Ratio Tests-III portray that the impact is increased from 65.795 to 212.503 by the introduction of occupation. Similarly it is increased from 65.795 to 164.682 by the addition of status in management. It clearly tells that occupation and status in management play a role in using bus in the city of Beirut.

Likelihood Ratio Tests-III

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	65.795 <sup>a</sup>	.000	0	.
Ocup	212.503	146.708	9	.000
MgStats	164.682	98.887	9	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

The reference category in table Parameter Estimates-III is “Daily”. This means that the system is comparing those use bus on a daily basis with all other variables and categories. First, we need to look at the significance value of the table. We can see that most of the values are insignificant. Only two values are significant which are as follows:

- Workers in Occupations (Ocup=1) using bus a few times a year.
- Workers in Occupations (Ocup=1) using car a few times a week.

We can understand from the above results that the trend of using bus is overall less in Beirut. The population surveyed for this research are more likely to use other modes of transport.

We can understand the effect of independent variable on dependent variable by looking at the Beta (B) values of the table. We can see that people in employment category (Ocup=2) who use bus few times a year are 14 times as less as self-employed who use it on a daily basis. This means the people using bus a few times a year are more than those using it on a daily basis. We can see that the same trend is in management status as well. Those higher up in management (MgtStats=1,2) tend to use bus 13 times as less in a year than ordinary job employees uses on a daily basis.

When we look at the comparison of self employed using bus on a daily basis to those using few times a month, we see that the trend is negative for employed class (-15.373).

There is a overall negative trend in most of the table when we make the comparisons of daily usage with weekly usage across different categories of occupation and management status.

The Classification-III table tells that the overall percentage of exploratory analysis is highly sufficient at 82.1%. This means that the independent variable is making a significant difference in the overall change in the dependent variable. There is one dependent variable and the comparison is to multiple independent variables which are making a significant impact in the model.

Parameter Estimates-III

Bus(q9d) <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
A few times a year	Intercept	16.021	815.046	.000	1	.984			
	[Ocup=0]	.094	.479	.039	1	.844	1.099	.430	2.807
	[Ocup=1]	-1.984	.505	15.423	1	.000	.137	.051	.370
	[Ocup=2]	-14.382	815.046	.000	1	.986	5.673E-7	.000	. <sup>b</sup>
	[Ocup=3]	0 <sup>c</sup>	.	.	0	.	.	.	.
	[MgStats=0]	-13.182	815.046	.000	1	.987	1.885E-6	.000	. <sup>b</sup>
	[MgStats=1]	13.610	418.057	.001	1	.974	814469.153	.000	. <sup>b</sup>
	[MgStats=2]	13.727	155.478	.008	1	.930	915295.629	4.158E-127	2.015E+138
	[MgStats=3]	0 <sup>c</sup>	.	.	0	.	.	.	.
A few times a month	Intercept	15.322	815.045	.000	1	.985			
	[Ocup=0]	1.444	.797	3.286	1	.070	4.238	.889	20.194

	[Ocup=1]	.592	.820	.520	1	.471	1.807	.362	9.016
	[Ocup=2]	-15.373	815.046	.000	1	.985	2.106E-7	.000	b
	[Ocup=3]	0 <sup>c</sup>	.	.	0	.	.	.	.
	[MgStats=0]	-16.265	815.045	.000	1	.984	8.632E-8	.000	b
	[MgStats=1]	.259	539.145	.000	1	1.000	1.296	.000	b
	[MgStats=2]	10.144	155.481	.004	1	.948	25445.466	1.148E-128	5.639E+136
	[MgStats=3]	0 <sup>c</sup>	.	.	0	.	.	.	.
A few times a week	Intercept	-2.068	1.080	3.664	1	.056			
	[Ocup=0]	1.361	1.137	1.432	1	.231	3.900	.420	36.240
	[Ocup=1]	2.485	1.118	4.940	1	.026	12.000	1.341	107.363
	[Ocup=2]	.458	1.211	.143	1	.705	1.581	.147	16.977
	[Ocup=3]	0 <sup>c</sup>	.	.	0	.	.	.	.
	[MgStats=0]	.276	.000	.	1	.	1.318	1.318	1.318
	[MgStats=1]	1.467	613.463	.000	1	.998	4.335	.000	b
	[MgStats=2]	1.440	229.833	.000	1	.995	4.219	9.794E-196	1.817E+196

[MgStats=3] 0°

- a. The reference category is: Daily.
- b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.
- c. This parameter is set to zero because it is redundant.

Classification-III

Observed	Predicted				Percent Correct
	A few times a year	A few times a month	A few times a week	Daily	
A few times a year	847	0	0	0	100.0%
A few times a month	68	5	0	0	6.8%
A few times a week	54	0	0	0	0.0%
Daily	64	0	0	0	0.0%
Overall Percentage	99.5%	0.5%	0.0%	0.0%	82.1%

5.7.4 HYPOTHESIS 4: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING SHARED TAXI SERVICE AT DIFFERENT TIME SPAN.

Looking at the level of significance in Model Fitting Information-IV table, we can see that the null hypothesis is rejected. It is a highly significant value at 0%, which implies that statistical theory is in support of the addition of a independent variable. This also means that the addition of independent variable makes an overall difference in the effect of the dependent variable. The relationship between them exists.

Log likelihood ratio in table Model Fitting Information-IV infers if the overall impact of independent variable is 0 on the dependent variable. We can see that the variation is significant. By the addition of independent variable, the dependent variable is reduced to 124.976. This means that the overall effect has occurred due to the addition of independent variable to the model.

Nominal Regression Model 4

Model Fitting Information-IV

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	330.394			
Final	124.976	205.418	18	.000

In the table Good-of-Fit-IV, we can see that we have Pearson and Deviance based results. According to that, model is adequately fit. For any model to be good, it should be accepted. This model is sufficiently adequate at 0% for both Pearson and Deviance.

Goodness-of-Fit-IV

	Chi-Square	df	Sig.
Pearson	222.335	9	.000
Deviance	68.342	9	.000



The Pseudo-R-Square-IV table shows a unit by unit comparison of the variables. We can see from the Nagelkerke and McFadden that 21.6% and 11.1% variation in the model is due to the addition of independent variable. Cox and Snell show a 18% variation in the model due to the addition.

Pseudo R-Square-IV

Cox and Snell	.180
Nagelkerke	.216
McFadden	.111

Likelihood ratio tests resolve the impact of independent variable on the dependent variable by computing variable-by-variable significance. The results in Table Likelihood Ratio Tests-IV tell that the impact is increased from 124.976 to 155.449 by the introduction of occupation. Similarly it is increased from 124.976 to 223.833 by the addition of status in management. It clearly tells that occupation and status in management play a role in using shared taxi as a mode of transport.

Likelihood Ratio Tests-IV

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	124.976 <sup>a</sup>	.000	0	.
Ocup	155.449	30.472	9	.000
MgStats	223.833	98.857	9	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

The reference category in table Parameter Estimates-IV is “Daily”. This means that the system is comparing those who use shared taxi on a daily basis with all other variables and categories. First, we need to look at the significance value of the table. We can see that there is a trend of some values being significant and others are not. The ones that are not significant include:

- Employees in Occupations (Ocup=2) using shared taxi a few times a year.
- Middle Management (MgStats=1) using shared taxi a few times a year.
- Other Occupations (Ocup=0) using shared taxi a few times a month.
- Workers in Occupations (Ocup=1) using shared taxi a few times a month.
- Senior Executive (MgtStats=1) using shared taxi a few times a month.
- Middle Management (MgtStats=2) using shared taxi a few times a month.
- Other Occupations (Ocup=0) using shared taxi a few times a week.
- Working class in Occupations (Ocup=1) using shared taxi a few times a week.
- Middle Management (MgStats=1) using shared taxi a few times a week
- Office worker (MgStats=2) using shared taxi a few times a week

The affect of independent variable on the dependent variable can be seen by looking at the Beta values of the table (B). We can see that people in employment category (Ocup=2) who use shared taxi few times a year are 6 times as less as self-employed who use it on a daily basis.

Comparing the values in the management status, we can see a negative and positive trend in the categories. This means that those in the lowest level of management (MgStats=3) use shared taxi lesser on a daily basis than those who are in the senior management; using it 8 times more in a year.

When we look at the comparison of self employed using shared taxi on a daily basis to those using few times a month, we see that the trend is negative for working class (-1.271). This means that working class use shared taxi almost 1.2 times less than self employed people’s daily usage. The results in the overall estimates show that the passenger usage of shared taxi is still less in Beirut.

There is a overall negative trend in most of the table when we make the comparisons of daily usage with weekly usage across different categories of occupation and management status.

The Classification-IV table tells that the overall percentage of exploratory analysis is sufficient at 72.4%. We discussed in the first section that the criteria is 50% or above. This means that the independent variables are sufficient to cause a significant change in the dependent variable. So there is no need to add more independent variables in order to impact the change.

Parameter Estimates-IV

Service (shared taxi-q9l) <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
A few times a year	Intercept	-4.155	3.316	1.570	1	.210			
	[Ocup=0]	-2.426	.803	9.117	1	.003	.088	.018	.427
	[Ocup=1]	-2.107	.889	5.615	1	.018	.122	.021	.695
	[Ocup=2]	6.430	3.313	3.766	1	.052	620.425	.938	410323.747
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	8.258	3.390	5.936	1	.015	3859.785	5.028	2963121.642
	[MgStats=1]	.596	.984	.367	1	.544	1.815	.264	12.485
	[MgStats=2]	2.066	.741	7.778	1	.005	7.890	1.848	33.694
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
A few times a month	Intercept	-19.712	.905	474.524	1	.000			
	[Ocup=0]	-1.271	.927	1.878	1	.171	.281	.046	1.728
	[Ocup=1]	.730	.995	.539	1	.463	2.075	.295	14.590

	[Ocup=2]	20.549	.994	427.072	1	.000	840348773.094	119688470.345	5900201234.119
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	20.809	.000	.	1	.	1089586938.474	1089586938.474	1089586938.474
	[MgStats=1]	-1.751	1.729	1.025	1	.311	.174	.006	5.146
	[MgStats=2]	-.498	.936	.283	1	.594	.607	.097	3.805
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
A few times a week	Intercept	-18.287	.866	445.823	1	.000			
	[Ocup=0]	-1.361	.886	2.358	1	.125	.256	.045	1.457
	[Ocup=1]	-.998	.994	1.010	1	.315	.368	.053	2.583
	[Ocup=2]	19.764	.946	436.181	1	.000	383310445.506	59981986.961	2449517014.655
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[MgStats=0]	19.790	.000	.	1	.	393415797.093	393415797.093	393415797.093
	[MgStats=1]	-2.319	1.681	1.904	1	.168	.098	.004	2.651
	[MgStats=2]	-1.018	.905	1.265	1	.261	.361	.061	2.129
	[MgStats=3]	0 <sup>b</sup>	.	.	0	.	.	.	.

a. The reference category is: Daily.

b. This parameter is set to zero because it is redundant.

Classification-IV

Observed	Predicted				Percent Correct
	A few times a year	A few times a month	A few times a week	Daily	
A few times a year	747	0	0	4	99.5%
A few times a month	101	0	0	0	0.0%
A few times a week	114	0	0	0	0.0%
Daily	67	0	0	5	6.9%
Overall Percentage	99.1%	0.0%	0.0%	0.9%	72.4%

5.7.5: HYPOTHESIS 5: OCCUPATION HAS AN EFFECT ON USING MODE OF TRANSPORT BETWEEN WORK/SCHOOL PLACE AND RESIDENCE

The null hypothesis is rejected if we look at the level of significance in Model Fitting Information-V table. It is a highly significant value at 0% that means that statistical theory supports the adding of an independent variable. It expounds that there is a relationship between the dependent variable and the independent variable.

Log likelihood ratio in table Model Fitting Information-V illustrates if the overall impact of independent variable is 0 on the dependent variable. We can see that the variation is significant. By the addition of independent variable, the dependent variable is reduced to 307.859.

Nominal Regression Model 5

Model Fitting Information-V

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	791.227			
Final	307.859	483.368	15	.000

For non parametric tests, we have to acquire results based on Chi-Square. In the table Good-of-Fit-V, we can see that we have Pearson and Deviance based results. According to that, model is adequately fit. For any model to be good, it should be accepted. This model is sufficiently adequate for both Pearson and Deviance.

Goodness-of-Fit-V

	Chi-Square	df	Sig.
Pearson	197.129	25	.000
Deviance	203.032	25	.000

We can see in the Pseudo-R-Square-V table that the Nagelkerke and McFadden show 39% and 15% variation in the model is due to the addition of independent variable. Cox and Snell is 37.2% variant in the model is due to the addition of the independent variable.

Pseudo R-Square-V

Cox and Snell	.372
Nagelkerke	.390
McFadden	.150

The results in Table Likelihood Ratio Tests-V portray that the impact is increased from 307.859 to 791.227 by the introduction of occupation. It clearly tells that occupation play a role in using the mode of transport to work/school in the city of Beirut.

Likelihood Ratio Tests-V

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	307.859 <sup>a</sup>	.000	0	.
Ocup	791.227	483.368	15	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

The reference category in table Parameter Estimates-V is “Shared Taxi”. This means that the system is comparing those using shared taxi on a daily basis with all other modes of transport

across different occupations. First, we need to look at the significance value of the table. We can see that most of the values are significant. The values that are insignificant are as follows:

- Others in Occupations (Ocup=0) using other modes of transport.
- Working class in Occupations (Ocup=1) using other modes of transport.
- Employed class in Occupations (Ocup=2) using car as mode of transport.
- Working class in Occupations (Ocup=1) using bus as mode of transport.
- Employed class in Occupations (Ocup=2) using bus as mode of transport.
- Others in Occupations (Ocup=0) using corporate or school bus as mode of transport.
- Others in Occupations (Ocup=0) commuting on foot.

We can understand the effect of independent variable on dependent variable by looking at the Beta (B) values of the table. We can see that those who used shared taxi across different occupations are significantly lesser than those who use other means of transportation.

We can also see that those who drive cars are as much as 3.7 times more than those who use shared taxi as their prime mode of transport. The percentage gets lesser as we move up the occupation. This means that self employed people might use a shared taxi and employed people might not.

It is also obvious from the data set that the trend of using corporate or school transport is higher in Beirut as compared to those who are using shared taxi. It is as much as working class using up to 3.8 times more than usage of shared taxi.

There is a trend of commuting by foot to schools and offices too. We can see that employed people go to workplace on foot 2.48 times more than self employed people. This also shows that there is a tendency of people to live close to their workplaces.

The Classification-V table tells that the overall percentage of exploratory analysis is barely sufficient at 51.4%. This means that the independent variable is making a difference in the overall change in the dependent variable. There is one dependent variable and the comparison is to multiple independent variables, which are making an impact in the model.



Parameter Estimates-V

Mode of transport between work/school place and residence-q21 <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Others	Intercept	2.890	1.027	7.915	1	.005			
	[Ocup=0]	-1.099	1.050	1.095	1	.295	.333	.043	2.609
	[Ocup=1]	-2.067	1.066	3.763	1	.052	.127	.016	1.022
	[Ocup=2]	-2.925	1.061	7.602	1	.006	.054	.007	.429
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
car drive	Intercept	4.060	1.009	16.208	1	.000			
	[Ocup=0]	-3.783	1.043	13.158	1	.000	.023	.003	.176
	[Ocup=1]	-3.860	1.057	13.322	1	.000	.021	.003	.167
	[Ocup=2]	-1.985	1.028	3.732	1	.053	.137	.018	1.029
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
bus	Intercept	1.792	1.080	2.752	1	.097			
	[Ocup=0]	-2.708	1.143	5.612	1	.018	.067	.007	.626

	[Ocup=1]	-1.638	1.127	2.112	1	.146	.194	.021	1.770
	[Ocup=2]	-1.940	1.114	3.033	1	.082	.144	.016	1.276
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
corporate/school trans.	Intercept	3.258	1.019	10.222	1	.001			
	[Ocup=0]	-1.159	1.041	1.240	1	.266	.314	.041	2.414
	[Ocup=1]	-3.846	1.093	12.387	1	.000	.021	.003	.182
	[Ocup=2]	-3.042	1.049	8.406	1	.004	.048	.006	.373
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.
on foot	Intercept	1.946	1.069	3.313	1	.069			
	[Ocup=0]	-2.169	1.110	3.816	1	.051	.114	.013	1.007
	[Ocup=1]	-4.143	1.303	10.107	1	.001	.016	.001	.204
	[Ocup=2]	-2.480	1.112	4.975	1	.026	.084	.009	.740
	[Ocup=3]	0 <sup>b</sup>	.	.	0	.	.	.	.

a. The reference category is: shared taxi/cab.

b. This parameter is set to zero because it is redundant.

Classification-V

Observed	Predicted						Percent Correct
	Others	car drive	bus	corporate/school trans.	on foot	shared taxi/cab	
Others	41	46	0	150	0	0	17.3%
car drive	22	289	0	33	0	0	84.0%
bus	21	31	0	10	0	0	0.0%
corporate/school trans.	10	62	0	204	0	0	73.9%
on foot	2	24	0	20	0	0	0.0%
shared taxi/cab	18	30	0	25	0	0	0.0%
Overall Percentage	11.0%	46.4%	0.0%	42.6%	0.0%	0.0%	51.4%

## 5.8 SUMMARY OF ACCEPTED/REJECTED HYPOTHESIS

### Hypothesis Statement Result

On the basis of the findings of the nominal logistic regression model, it can be seen that relationships exist between the dependent and independent variables. Below is a summary of the results:

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No.	Hypothesis	A/R
H 1	Occupation and management status has an effect on using car as a driver at different time spans	Accepted
H 2	Occupation and management status has an effect on using car as a passenger at different time spans	Accepted
H3	Occupation and management status has an effect on using bus at different time spans.	Accepted
H4	Occupation and management status has an effect on using Shared Taxi service at different time span.	Accepted
H5	Occupation has an effect on using mode of transport between work/school place and residence	Accepted

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Total number of Hypotheses: 5

Accepted: 5

We can see that the five hypotheses selected for the study were all accepted. This is due to the fact that there is a strong relationship between occupations of a person to the choice of transportation. Also, there is a strong relationship between a person's status in management and his choice of transportation. We intended to use the connection in order to understand what drives a person to not use the public transportation and instead opt for other services and through this study we have been able to find this out. We can see that in Beirut, it is the person's occupation and management status that compels him to choose a certain type of service. The findings of this

research can help the policy makers in Beirut to create change in the region i.e. to discourage people to use private transportation and to encourage them to use public transport.



# CHAPTER SIX

## Discussion and recommendations





## **CHAPTER SIX: DISCUSSION AND RECOMMENDATIONS**

### *6.1 INTRODUCTION AND OVERVIEW*

The last chapter analyzed the data that was obtained from the survey collection. The chapter drew a relationship between occupation and management status to the selection of mode of transportation. The previous chapter empirically proved the relationship between occupation and the choice of mode of transport. The attitude of people gets different when they earn more income or if they have a higher status in management. They avoid public transportation and try to use their own private transportation.

This research has been a profound exploration on the subject matter. To give readers a quick summary of the entire study and give a comprehensive information for further analysis this chapter has been verbalized. This final chapter of the study will give all the details in an orderly and comprehensive manner. Warming up with the presentation of the findings the first subsection of the chapter will clarify all the theoretical and empirical perspectives associated with the study and will thereby verbalize a final word. This section will be a concise review of empirical findings reinforced by extant literature thereby using both the primary and secondary sources of information in a balanced way.

Being the last chapter of the study it is necessary that by the reader should be in a position to properly evaluate whether the research findings met the aims and objectives or not. For this, researcher in the next section will dissect research findings keeping in mind the main objectives.

The successive section will elaborate some feasible recommendations for the various stakeholders involved in the study. The recommendations" section will explain the future scope of the research. It will articulate the future prospects of the study, opportunities for future researchers and scope of the study. Finally, the researcher will point out a few limitations that might have been a obstruction in achieving the best possible results.

### *6.2 DISCUSSION OF RESULTS*

#### **6.2.1 HYPOTHESIS 1: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING CAR AS A DRIVER AT DIFFERENT TIME SPANS.**

In the first part of the questionnaire, general questions related to the gender, living conditions and educational qualifications are asked. The questions are laid out in a way so that it is easy for the user to fill the answers. The questionnaire builds the foundation of the research by asking the related questions about the head of the family. The second part of the questionnaire asks about the choice of mode of transportation. It has been put down in a way so that the users will first give

information about their choice of transportation and then later questions related to profession and occupation are asked. It was found that people who are employed tend to use cars as drivers nearly 17 times more than those who are self-employed. The chance of a self-employed person to own a car is far higher than the employed person but the preference to use the car are lesser. This could be due to the fact that a lot of organizations pay their employees a transportation allowance. Moreover, the rising fuel prices in Lebanon are also a reason for discouragement and self-employed people tend to an attitude to cut expenses.

Similarly with regards to status in management, the higher the status in management, the more likely a person is to use his own car as a driver. This can be attributed to the fact that the higher you are in management, the more flexible your schedule becomes and in order to follow that schedule, a lot of people opt to use their own cars.

These results are in line with the findings of earlier researches done in the same area (Nurdden, 2007; Hess, 2001; Garvill, 1999). The attitude to use public transportation has always been discouraging in Beirut. People usually prefer using their own personal transportation. A part of it is due to the quality of the public transport and also to the lag in maintaining schedule. Therefore, people prefer using their own cars for major travels including those to work.

Status in management also plays a role in the amount of money you are earning. The better you are economically, the more you are able to spend. Thus, the trend of those higher up the ladder using more of their own cars is attributable to the fact that they have more money to spend.

Also to contribute to this is the ease of ownership of car in Lebanon. The government has created means to simplify the process to own a car and thus more people are buying cars for themselves. Moreover, if you are living in areas, which are farther off from the city center, using your own car is more feasible and economical than public transportation and therefore, people prefer having their own cars.

#### 6.2.2 HYPOTHESIS 2: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING CAR AS A PASSENGER AT DIFFERENT TIME SPAN.

It is imperative to understand the choice of using car as a driver and as a passenger. The reasons are many. The first reason for using car as a passenger could be due to having a driver, who can take you to places. Usually drivers are hired because of lengthy distances, excessive commute, parking space issue and bad road network. Also, the ease of hiring a driver makes the commute easy for most of the people. Hence, people prefer being a passenger in the comforts of their car if and when they can afford it.

It has also been observed from the results that status in management has a stronger contribution in using car as a passenger than occupation. With occupation, having a car makes more of a difference, however, in case of using it as a passenger i.e. having a driver to drive the car around, your status in the organization play a much important role. As people move up the ladder in management, transportation allowance allows people to afford a driver and a car.

### 6.2.3 HYPOTHESIS 3: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING BUS AT DIFFERENT TIME SPANS.

In the analysis conducted in this study, it has been found that occupation and management status are contributors in the usage of bus. However, it has been seen from the data that occupation plays a key role from the two. Self-employed and employed people are seen not using bus that much. However, it has been seen that people in “other” occupations are more likely to use buses than all other occupations.

The effect of status in using bus is almost uniform across all levels. This means that bus usage is more dependent on occupation than the status in management. It can be seen that people who are working in jobs where the salaries are very minimal and they are most likely not having their personal transport end up using buses. It can also be predicted from the general population behavior that buses are not very popular in the city of Beirut.

### 6.2.4 HYPOTHESIS 4: OCCUPATION AND MANAGEMENT STATUS HAS AN EFFECT ON USING SHARED TAXI SERVICE AT DIFFERENT TIME SPAN.

It has been observed from the results that our two contributing factors; occupation and management status have a significant role in choosing taxi as the mode of transportation. However, it has also been seen from the results that status in management takes a bigger chunk of pie than occupation in taxi usage. This is due to the fact that as we go up the status in management, allowance for travelling are generally paid by the organization and taking a taxi is more convenient than taking your own transportation. Moreover, if you are employed, you are more likely to be working in the city center and because of traffic; it takes longer time to reach and is quite tiresome. However, taking a taxi makes the drive convenient, it also saves from finding a parking space in the city.

### 6.2.5 HYPOTHESIS 5: OCCUPATION HAS AN EFFECT ON USING MODE OF TRANSPORT BETWEEN WORK/SCHOOL PLACE AND RESIDENCE

The researcher was of the view that the research would be void if the question of preferred mode of transportation to work or school has not been asked. So, the researcher made it mandatory to ask since it gives a foundation of the most used transport. The transportation used to get to work/school is usually the one which is more reliable, efficient and comfortable. The factor of cost comes usually later. However, it can be seen from the results that the most used mode of transportation in Beirut is car. Car usage is usually considered the most preferred mode of transportation. After car usage, its corporate transportation/school buses. We can see from the results that private transportation is preferred in Beirut over public transport. This also gives a clear picture of the sad state of affairs of the public transportation in Beirut.

### *6.3 MAJOR FINDINGS*

The researcher worked on this study with a very clear direction and throughout the course of the study rigorously worked towards achieving the positive outcome. To handle the study in its true spirit, research considered many factors, grouped them according to their themes and derived five major themes i.e. car usage as driver, car usage as passenger, bus usage, taxi usage and work-school transportation usage behavior.. Hence, researcher conducted this study in a very thematic way where each theme was identified and rest of the work was done keeping them in mind. The application of Multinomial Logit was the most suitable method for data analysis since the data didn't meet the conditions of parametric tests.

The research findings of the study clearly show that occupation and status in management play a role in the choice of transportation. However, their role different in the choice of transportation is different. To see which factors are of vital importance, researcher kept in mind various dimensions and computed variables that are more significant.

The researcher is of the opinion that sample composition also plays a critical role in the type of results created. This argument has been supported by Matsumoto and Vijver (2010) and Coyne (1997) in their respective researches too. Therefore, special attention was given to this aspect. Though, the sample respondents hailed from different parts of Beirut and the respondents that took part in the research study were randomly selected, the sample was slightly dominated by educated, employed and self-employed people.

While analyzing the usage of car as a driver, it was observed that occupation and status in management play a very vital role. It could however be seen that occupation is predominant in the selection rather than management status. We could see from the results that people who are employed are more likely to be using car as a driver than people in other occupations. It was also observed that self-employed people use cars as less as 15 times than employed people. This could be due to the fact that employed people are given transportation allowance and they have more access to auto-loans than self-employed people. Also, employed people are generally travelling farther to reach their workplace, while self-employed have their work close to their homes. It was also seen that the trend of using cars was very less in people who are in occupations that don't pay much. So we can see that your salary and allowances pay a key role in usage of car as a driver.

On the other hand, the second observation was based on using car as a passenger. It has been seen that the one part of the result was similar to the results before, which is usage of car was more by employed people. However, for usage of car as a passenger, status in management played a more important role. It has been implied from the research that the higher the status in management, the more likely you are going to use the car as a passenger and the lower the status in management, the less likely you are going to use the car as a passenger. This can be contributed to the fact that people in higher status invest more energy and time in their work. Most of the work places are centralized around city center, which is far away from the modern

community suburbs. So travel times between home and work place is a lot. In other to save energy from driving, people tend to use drivers to go to work. Moreover, this also shows that hiring a driver is also a trend that comes with higher status in management.

Further, the researcher observed from the data that occupation and status in management also play a role in using bus. However, it was seen that occupation makes more contribution than status. It was seen that people who are in “other” occupations in the data have a bus usage trend. However, it has not been seen that for the rest of the occupations, there is barely any usage of bus. It has also been seen that at all levels in management, bus usage is minimal. This is due to the fact that there are large distances to be covered in Beirut and buses with their multiple stops, make the journey longer and tiresome. Moreover, the punctuality and quality of bus service is still very poor and thus people prefer using other modes of transport than buses.

It has also been observed that occupation and management status are contributors in the selection of taxi as a mode of transportation. It has been seen that management status plays a more dominant role than occupation in the usage of taxi. It has been seen that as we go up the levels in management, the usage of taxi is more likely to occur. This can be due to the fact mentioned earlier that a lot of organizations pay for the transportation allowance and thus people prefer using taxi service. It can also be said that with to save from the congestion traffic and parking hassles, people prefer taking a taxi service to their work.

Lastly, the researcher finds out what mode of transport people prefer while going to work or school. It has been seen that the highest rate of usage is cars for work and school. This can be easily contributed to the quality and efficiency of public transportation system. Second preference is the work or school bus or transport. This means that some organizations provide transportation to their employees and they prefer using it over other modes of transport. For children, school buses are more preferred.

This research gives a very clear picture of the public transportation system of Beirut and can be of great help to analysts and planners in modifications in how to improve the system and to attract people in using more public transportation than private transportation.

## *6.5 RECOMMENDATIONS*

After completing the basic rituals of citation of research, the researcher at this point will present a set of recommendations that directs towards various individuals, institutions and authorities. The recommendations on the chapter are what the researcher has inferred through the research, not directly connected to the research as such.

The essence of this section is to make necessary improvements that can be made in order to provide a pathway to people to encourage the use of public transportation, thereby optimizing the positive outcomes. The primary purpose of any research is to become a positive contribution in

the field of study and give findings that can open new horizons for discovering and finding solutions. Suffice to say, it is this section that addresses the above stated ambition.

At this juncture the set of recommendations that the researcher will like to put forward for the readers include:

#### **6.5.1 TO DISCOURAGE USAGE OF PRIVATE TRANSPORTATION**

As the research findings showed, majority of the people are using their own transportation. This automatically makes “discouragement of private transportation” first and the most appropriate step towards reducing the traffic burden and to encourage the flow towards using public transportation. However, it will be a very broad statement to give; more specifically researcher will suggest that the governments should ensure in order to start the process.

##### ***6.5.1.1 Increase Car prices***

In order to make sure that the population stops using private transportation; the first step that the government can take is to increase the prices of cars. The government can announce uniform increase the prices of cars and also make the process of car ownership lengthy. This will discourage people to buy cars especially first time car owners as the price of the car will be beyond their budget.

##### ***6.5.1.2 Increase tax on cars***

The government can also impose taxes on car ownership. The tax can be increased if someone owns more than one car. This will not only discourage car ownership as such, but will also restrict people to have only one car per household. The tax amount should be decided according to the average wage level in the country and should be slightly higher. If the tax is very small, people will easily pay it off year by year and would prefer keeping the car with them. The purpose of the tax is to discourage car ownership and thus reduce the burden of cars on road and encourage people to use public transportation.

##### ***6.5.1.3 Introduce tolls and increase them on an annual basis***

According to the key research findings, people prefer using their own cars to travel to their workplace. In order to discourage people to use their own cars is to put a toll on the main highways that lead to the city center. When people will not have alternate ways to get to their work, they will be forced to pay the toll. The toll should increase on a year-by-year basis. This will demotivate people to take their cars on the highways. If people chose to take alternate routes, it would be lengthy and time consuming; hence the purpose of taking your own car to work will fail.

##### ***6.5.1.4 Increase gasoline prices***

Researcher is of the opinion that when the gasoline prices will increase in the country overall, people will find it hard to afford their cars on a day-to-day basis. Thus, they will be discouraged to use their own cars and will have to shift to alternate ways. The first alternate way could be usage of car-pooling. As the gasoline prices keep on increasing in the country, over time car-

pooling will also become expensive and people will gradually shift to public transportation. It is necessary to make such changes in the country if the government aims to resist people from using their own cars. If we look at the bigger picture, more cars on the road causes congestion and this will lead to the future risk of road damage, pollution and the need for road expansions. If the government controls the amount of cars on the road, less road maintenance and expansion and lesser pollution will be the result.

#### ***6.5.1.5 Introduce congestion charges on major roads***

Since most of the population is using their own cars for work, it is imperative that rush hours traffic will be a hassle in Beirut. This means that roads will be congested, traffic will be slow and there will be increasing number of cars on the road everyday. This leads to major delays in reaching from one point to another. In such cities, people prefer timings where the traffic is reduced. However, with restricted 9 am to 5 pm office hours, it is mandatory to take the same road to the city center and face the same amount of traffic everyday. Therefore, to discourage usage of the main road to city center, it is necessary to introduce tolls on all the roads that lead to the city. The toll should be levied at the start of the city. Any vehicle using the road should be bound to pay congestion charges during a certain time-slot on a weekday. This will dispirit people from bringing their cars to the city.

#### ***6.5.1.6 Introduce parking fees across the city center***

To discourage people from bringing their cars to the city, the most feasible method is to introduce parking fees across the city center. When the parking fee is introduced, it should be levied on a time-slot basis. No car should be allowed to be parked for more than 4 hours. There should be strict monitoring of parking and heavy fines should be introduced for violators. Moreover, “No Stopping” zones should also be made across the city. Roads with heaviest traffic should have a maximum parking zone of 1 hour. The parking time limit should be made according to rush hour traffic load. This will make it inconvenient for people to bring their cars to the city and they will start using other modes of transportation.

### **6.5.2 TO ENCOURAGE USAGE OF PUBLIC TRANSPORTATION**

The research findings indicate that though usage of private transportation saves times for most of the population but it introduces other issues that the government has to deal with. Main concerns for the government are handling traffic loads, maintenance of roads across the city and pollution. In order to avoid all of the above, it is necessary to divert the population from the usage of private transportation to the usage of public transportation. This shift requires a lot of measures from the government. Some of the recommended measures have been elaborated below.

#### ***6.5.2.1 Improve Quality of Public Transportation***

While stressing on creating vital opportunities researcher indeed is stressing on improving job market structure of the country. Doing this will not only create opportunities for people living in the country, but will also send a positive message to expatriates settled abroad. Such vital

opportunities will give them confidence that the infrastructure and policy structure in the country has improved and coming back to the home country will not be mistake or losing an opportunity that they already have in non-native country.

#### ***6.5.2.2 Availability***

As aforementioned „exchange rate“ play a vital role in determining the direction of human flight, implying that pay structure is of great importance. Offering a competitive pay scale might act as a lucrative option for expatriates and help play a role in bringing them back. Apart from salary, there are many other incentives and/ or facilities that a country can give to the returnees. For example a person comes back to home country while his family is still in the non-native land governments, companies, etc. can give him a ticket annually to see his family.

#### ***6.5.2.3 Punctuality***

Till this juncture we have established one point that a country’s skilled human capital abroad can act as catalyst in growth process of home country. Despite governments taking extensive steps to bring the skilled human capital back, there is a probability that people who are now settled abroad will not like to come back and start all over again. In such scenarios, governments should launch programs that would invite expatriate for a short term and ask them to educate their countrymen during their brief stay. Though, it is not the exact solution to the problem, but to an extent can serve the purpose.

#### ***6.5.2.4 Offer promotional prices***

The government should offer special packages on public transportation to encourage people to take the leap. This can include weekly, monthly and annual packages. There should be special discount cars for students, elderly and the disable. People will start calculating the cost-benefit analysis of using public transportation and thus, it will become easier for them to shift from their own private cars to public transport.

#### ***6.5.2.5 Advertisement***

In order to encourage people to use public transportation, there is a need that the government using public welfare messages across the country to encourage people to use public transportation. This should be done by promotion through TV channels, billboards and paper and social media. The benefits should be highlighted and the effect of private transportation on the environment should be emphasized. Government should allocate a fund for advertisement and once the flow moves towards usage of public transportation, the funding can be reduced.

## ***6.6 CONCLUSION***

This chapter presented the findings of the data analysis in a verbal manner. It also emphasized on what measures the government needs to take in order to entice the use of public transportation



and discourage the use of private transportation. This chapter can be noteworthy and usable for further research. The next chapter represents limitations and perspective of the research.



# CHAPTER SEVEN

## Conclusion and further research



## CHAPTER SEVEN: CONCLUSION AND FURTHER RESEARCH

### *7.1 CONCLUSION*

The issue of non-usage of public transportation is not of secondary importance. As evident from the review of extant literature too, the notion of using public transportation is deep rooted in the „formation“ and welfare of society. Hence, when these activities are carried out, they should be carefully monitored as it has the potential to leave long lasting impact. For any nation and government to succeed, it is necessary that the population use public transportation. This public transportation makes it easier for government to monitor the flows and understand the expansion projects for any city or country. Review of extant literature also elucidate that individuals at large has a stake in the numerous engagements of society; therefore, they try to explore and exploit the best possible opportunities for them in various cultures and societies. This ultimately gives rise to choosing the best of the transportation modes available.

Public transportation avoidance is not a contemporary issue in Beirut. It has been there for a very long time. This is a loophole not only in a society like Beirut but a lot of well-developed nations are suffering in the same way. It is necessary for governments of such countries to educate the population on the benefits on using public transportation. They also need to make it available and convenient for the population so they prefer it over other modes of transportation.

In this PhD thesis, researcher tried to study the two factors involved in choice of transport mode simultaneously and have made an attempt to explore how these factors that help in the choice. To present a sound, reasonable and rational argument researcher has presented conclusions that are justified by empirical findings and backed by theoretical evidence.

The study inaugurated with specifying research objectives, followed by scrutinizing extant literature, empirical testing and thereby developing a link between research finding and objectives. The study basically attempted to explore the impact of occupation and management status in choice of mode of transportation. This chapter concludes the research that suggest that both of them have a direct and positive impact on the decision making ; however the impact of each is different in each mode of transport, time span and usage. This chapter being the last chapter of the study has categorically studied all the research objectives in light of research findings and has developed a direct connection between each of them.

In addition to this, the chapter produces some feasible recommendations that can help dealing with this dilemma. Researcher in this final chapter also gives some recommendations and future research directions to anyone who might be interested in reconnoitering this topic ahead. The chapter also shed light on some issues of further research unraveled in the course of the study and those if incorporated will improve the quality of research significantly

## 7.2 PERSPECTIVE OF THE RESEARCH

The research was done as an agreement with S&A Company and the researcher. The purpose of the research was to dig the reasons of nearly non-existent usage of public transportation in Beirut. The company wants to work with the government of Beirut to encourage the usage of public transportation in order to reduce fuel consumption and eventually carbon emission. Moreover, S&A has an establishment in Belgium and it was observed that the population uses public transportation at a significantly high rate and they wanted to turn the table in Beirut. As a starter, they wanted to analyze the factors that motivate a user to choose a certain type of transport. This is where the services of the researcher were utilized. As we can see from the research that occupation and management status play a vital role in choice of transportation. Underlying factor maybe the amount of money a person earns but with the questionnaire used, the researcher drew these results.

### 7.2.1 APPLICATION OF THE AGENT BASED MODEL

The agent-based model used in the research can be used in the exact way or with extensions for application in the city of Beirut. The government can start the application from the city center and then extend it to the whole city. With further modifications, it can later be applied to the whole country. It is deemed necessary to mention here that even though the model can be applied at full but to cover the shortcomings in a reasonable manner, it should be applied in parts and phases. The current model is based on the stigmergy communication, i.e. the communication throughout the environment. It is outlining the effect of social and economical changes on individuals.

Further changes to the model can also give interactions among the individuals; in order to measure the effect of an social and economical change on individuals then they receive these changes through direct interactions, and not through environmental bodies.

### 7.2.2 TRAINING AND EDUCATION

In order to bring any change in the environment, it is necessary to educate the population. In order to bring the shift of population from private transportation to public transportation, it is necessary that educating the masses be executed. This can be done by public welfare programs and training at schools and workplaces. The government should continuously fund programs on television, social media and print media about the harms of usage of private transportation on the environment. At the same time, they should promote the ease, punctuality, comfort and cost of the public transportation. It may take time but it should be done with persistence.

### 7.2.3 CONSULTING

The results of the research can also be used for road and traffic consultants. They can use the results to filter type of users and their priorities on the road. Passenger flows can be measured and shifts can be made in the flows by introducing factors that will change user perspective. Moreover, the results can also be used to generically understand the population behavior of Beirut.

### 7.2.4 SIMULATION OF MODEL

The findings of the research can be used to create a simulator of shift in traffic flows in Beirut. This will also be an enhanced step in the research. The simulator will be created by the technical team funded by the S&A company. The technical staff will create the simulator and implementation will be done at a future stage. The company plans on using this tool within projects that will be setup by the researcher in Lebanon in conjunction with Lebanese local road authorities.

## 7.3 LIMITATIONS

There are certain limitations that the researcher had overcome while bringing this research to completion. It is necessary to highlight those hindrances as they make data collection and other research tasks more tiresome and the quality of the research is affected because of it. As the fact establishes that having limitations is not out of place. Thus, a few most prominent hindrances include:

- 4 **Time Limitation:** The researcher had a limited time frame that has affected the efficacy of the research. Time limitation affect the quality and validity of data collected which can in return hinder the achievement of research aims and objectives (Crowther and Lancaster, 2009). Given more time, the study would have completed in a more orderly and intelligent manner.
- 5 **Resource Limitation:** Limitation of resources mainly means financial constraints. The research had very limited finances available to complete the research. Lack of finances affected the data collection and the researcher was not able to cover other cities of Lebanon and had to restrict to Beirut. Moreover, if there were finances available, the population could have been expanded for the study.
- 6 **Access Limitation:** The results of the data collected were obtained through primary data collection. The researcher had to request a lot of people and knock on many doors to get the data filled. However, the researcher wanted to get the data collected from bureaucrats, politicians and elite class of Beirut but the access to them was denied. The results of the data collected lack the attitude and choice of a major chunk of people that might have affected the overall result.. Remenyi (2007) and Cooper & Schindler (2006) in their research work

acknowledged access limitation as one of the major limitations that could restrict researcher from appropriately representing the results.

- 7 **Limited Respondents:** Choice of mode transportation can be adequately addressed and explained by the diversity of the sample population. However, in this case the researcher was unable to reach many people within Lebanon and internationally whose input could add value to the research. Thus, the diversity in the sample was quite limited.

#### *7.4 FURTHER RESEARCH*

After the arguments presented, researcher moves one step further and presents the directions for any future research that may be conducted in this are. The future scope of this research is likely and bright. Anyone who is interested in this topic can take this study ahead and the study is open for post-doc analysis as well.

However, before researcher presents the practical implication of the study, it is important to mention here that a major limitation of the research study is the self-report questionnaires employed for data collection. The same questionnaire was used to gather data for all the variables. This can give rise to “common method variance”; hence, this loophole should be fixed.

Currently the research used both the data sources and presented research findings in a basic research paper format. Nevertheless, the study can be conducted in various other formats too; it can be conducted as a case study analyzing different occupations, it can also take form of a comparative study drawing comparison between two countries, etc. Carrying the current methodology ahead or opting for any other methods will bring further light on the study.

Anyone who is interested in taking this study ahead should also consider the diversification of the sample very critically. The sample used in this study has elements of diversity, but somehow number of employed and educated people is slightly greater. Future researchers should take steps towards forming a relatively more diverse and neutral sample as this will help them getting a clearer perspective across all sectors.

The main aspects covered by the researcher in this study are analyzing how occupation and management status play a role in choice of transportation. Due to some restrictions of the study such as time and cost constraint, some issues could have been let go by the researcher that can be utilized for further examination. Hence, the researcher will advise future researchers to make up for those areas too. A main aspect that the researcher missed was contacting various transportation organizations. Incorporating personnel directly from the transportation sector would have improved the quality of research findings manifold.





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# APPENDIXES



## **APPENDIX 1: QUESTIONNAIRE USED IN THE RESEARCH**

RESEARCH TRANSFER BEHAVIOR FLADERS

People questionnaire1

The

questions are answered in different ways:

- 1. There are a number of options for answering each other: circle the number before your answer.  
*For example:* Do you use a car (car, delivery van or truck) during the performance of your work?  
 Circle the correct number, one answer possible  
 1 always  
 2 occasionally

3 never

- 2. There are some empty boxes: note your answer in the empty boxes.

*For example:* Number of persons in the family:

- 3. Sometimes it is possible that you do not find your answer in the list and that you answer 'other'. In that case, encircle the number before 'other' and write your answer on the line, preferably in capital letters.

*For example:* What kind of vehicle? 1 car  
2 van  
3 other: MINIBUS

- 4. Attention: not all questions have been answered by everyone: follow the instructions carefully.  
*For example:* Question 10 3 retired → go to question 30

If you would like more information or help filling out this questionnaire, please call our free green number 0800-498.81 between 13 and 21 o'clock (from Monday to Friday).

1 In implementation of article 4 of the law of 8 December 1992 for the protection of privacy for the processing of personal data, you will be informed of the following:

- 1. Holder or. processor of the database: Flemish government (Department of Mobility and Public Works, Department of Mobility and Traffic Safety)
- 2. The data will be used for research into the travel behavior in Flanders

3. Additional information can be obtained from the register held by the "Commission for the protection of privacy" (processing identification number = VT005000367).
4. Everyone has the right to access the data applicable to him / her and the right to request the correction thereof.

## PERSONAL QUESTIONNAIRE

---

1. In what year were you born?
- 

19\_\_ or 20\_\_.

2. Your gender is:
- 

- 1 male
- 2 female

3. Do you live with a partner?
- 

- 1 yes → go to question 5
- 2 no

4. Which description best fits your living situation?

Circle the correct number, one answer possible

---

- 1 I live alone → go to question 6
- 2 I live without a partner and with children → go to question 6
- 3 I live with my parents in a one-parent family → go to question 6
- 4 I live with my parents in a two-parent family → go to question 6
- 5 other living situation → go to question 6

5. Which description best fits your living situation?

Circle the correct number, one answer possible

---

- 1 I live together with a partner (married or not) but without children
- 2 I live together with a partner (married or not) and with children
- 3 other living situation

6. Are you in possession of a driving license to drive a car?
- 

- 1 yes
- 2 no → go to question 8

7. How many years are you already in possession of this driving license?

If less than 1 year, write 0

---

For \_\_ years

8. Indicate your highest diploma or certificate.

Circle the correct number, one answer possible

---

1 none

2 primary education

3 secondary education: general: not fully finished

4 secondary education: other (technical, professional, art, sports ...): not complete  
finished

5 secondary education: general: fully finished

6 secondary education: other (technical, professional, art, sports ...): completely finished

7 higher non-university education

8 university education

---

#### PERSONAL QUESTIONNAIRE

---

8b. Are you the head of the family?

---

1 yes → go to question 9

2 no

8c. What is the marital status of the head of the family?

Circle the correct number, one answer possible

---

1 Unmarried

2 Married

3 Widow (to)

4 Divorced

5 registered cohabiting (ENQ: d.i. cohabitation contract signed at the town hall)

8d. In which year was the head of the family born?

---

19\_\_

8e. What is the gender of the head of the family?

---

1 male

2 female

8f. What is the highest earned diploma or certificate from the head of the family?

Circle the correct number, one answer possible

---

- 1 none
- 2 primary education
- 3 secondary education: general: not fully finished
- 4 secondary education: other (technical, professional, artistic, sports): not completely finished
- 5 secondary education: general: fully finished
- 6 secondary education: other (technical, professional, art, sports): completely finished
- 7 higher non-university education
- 8 university education

---

#### PERSONAL QUESTIONNAIRE

---

9. Indicate for each of the following means of transport how often you use it.

Circle the correct number, one answer possible per means of transport

---

Car as a driver	Car as a passenger	Train
<ul style="list-style-type: none"><li>1. Never or less than once a year</li><li>2. one to a few times a year</li><li>3. one to a few times a month</li><li>4. one to a few times a</li></ul>	<ul style="list-style-type: none"><li>1. Never or less than once a year</li><li>2. one to a few times a year</li><li>3. one to a few times a month</li><li>4. one to a few times a week</li></ul>	<ul style="list-style-type: none"><li>1. Never or less than once a year</li><li>2. one to a few times a year</li><li>3. one to a few times a month</li></ul>

week 5. daily	5. daily	4. one to a few times a week 5. daily
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Bus (De Lijn, MIVB of TEC)	Tram (De Lijn, MIVB of TEC)	(pré)metro (De Lijn, MIVB of TEC)
<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>	<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>	<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>

Motorcycle	Mustache moped	Electric bike
<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>	<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>	<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>

Bicycle
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1. Never or less than once a year
2. one to a few times a year
3. one to a few times a month
4. one to a few times a week
5. daily

PERSONAL QUESTIONNAIRE

Taxi	Autocar	Airplane
<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>	<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>	<ol style="list-style-type: none"> <li>1. Never or less than once a year</li> <li>2. one to a few times a year</li> <li>3. one to a few times a month</li> <li>4. one to a few times a week</li> <li>5. daily</li> </ol>

10. Are you currently doing a professional activity as a main occupation:

- 1 yes
- 2 no → go to question 12

11. For what reason are you not professionally active?

Circle the correct number, one answer possible

- 1 student, student → go to question 18
- 2 job seeker → go to question 30

- 3 retired → go to question 30
- 4 incapacitated for work → go to question 30
- 5 working exclusively in their own household → go to question 30
- 6 others: ..... → go to question 30

12. What is your main occupation?

Circle the correct number, one answer possible

---

- 1 worker → go to question 15
- 2 employee (public or private sector)
- 3 self-employed → go to question 14

13. You are:

Circle the correct number, one answer possible

---

- 1 member of the general management, senior executive → go to question 15
- 2 member of the middle management  
(not part of the general management) → go to question 15
- 3 other, mainly office work → go to question 15
- 4 other, little or no office work → go to question 15

14. You are:

Circle the correct number, one answer possible

---

- 1 farmer
- 2 professional, entrepreneur or trader with 5 employees or less
- 3 professional, entrepreneur or trader with 6 employees or more
- 4 free profession (doctor, lawyer, expert, accountant ...)
- 5 other: .....

## PERSONAL QUESTIONNAIRE

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15. You work:

Circle the correct number, one answer possible

---

- 1 only during the day
- 2 only during the night

- 3 in shifts without night shift
- 4 in shifts with night shift
- 5 in a different situation

16. You have:

Circle the correct number, one answer possible

---

- 1 daily (approximately) the same working hours, largely determined by your employer (fixed or sliding working hours)
- 2 daily (approximately) the same working hours, largely determined by yourself
- 3 regularly different working hours, largely determined by your employer  
(for example overtime)
- 4 regularly different working hours, largely determined by you

17. Are you using a car (car, van or truck) during the exercise of your work?

Circle the correct number, one answer possible

---

- 1 always
- 2 occasionally
- 3 never

18. Do you have a permanent work or school address?

With fixed work or school address we mean the address where you go to work more than half of the time or to go to school or to take classes.

---

- 1 yes, and this address is not at home with me
- 2 yes, but this address is at my home → go to question 30a
- 3 no → go to question 30a

19. Where is your permanent work address or school address?

---

Township: ..... (if abroad: note it country):  
.....

Postal Code: .....

street: ..... Nr.: .....

20. How far is your permanent work or school address for your place of residence?

Write down the distance that you usually actually travel. Kot students take the distance to their kot. Record a distance of less than 1 kilometer (for example 500 meters) as follows: 0.5 km

---

|\_|\_|\_|\_| km.

21. In what way do you most often go to work or to school? Please indicate the main mode of transport.

With main transport mode we mean the mode of transport on which you travel the longest distance. *Circle the correct number, only one answer possible.*

- 
- 1 with the car, as a driver
  - 2 with the car, as a passenger
  - 3 by train → go to question 25

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PERSONAL QUESTIONNAIRE

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- 4 by tram / (pre) metro (De Lijn, STIB, TEC) → go to question 25
- 5 by bus (De Lijn, STIB, TEC) → go to question 25
- 6 with corporate or school transport → go to question 25
- 7 with the moped / moped → go to question 25
- 8 with the engine → go to question 25
- 11 with the electric bike → go to question 25

9 with the bicycle → go to question 25

10 on foot → go to question 25

22. Do you always find easy parking space for the car when you go to work or go to school?

Circle the correct number, one answer possible

---

1 without problems

2 with some difficulty

3 with a lot of effort

23. Do you have to pay for parking your car?

---

1 yes

2 no → go to question 27

24. How much do you have to pay per month (do you want to divide an annual amount by 12)?

Circle the correct number, one answer possible

---

1 less than 50 € → go to question 27

2 from € 51 to € 100 → go to question 27

3 more than 100 € → go to question 27

25. Imagine that you would come to your work / school as a driver or as a passenger, would you always find parking space for the car?

Circle the correct number, one answer possible

---

1 without problems

2 with some difficulty

3 with a lot of effort

4 do not know

26. Imagine that you would come to your work / school as a driver or as a passenger, would you have to pay for the parking space?

---

1 yes

2 no

3 do not know

If you are a student go to question 31

27. Do you do carpooling?

Carpooling is a system in which you, along with other workers, use the same car for commuter traffic.

Circle the correct numbers, multiple answers possible

---

1 yes, with 1 or more family members

2 yes, with 1 or more people from the same company

3 yes, with 1 or more people from another company

4 no → go to question 30

#### PERSONAL QUESTIONNAIRE

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28. How many times do you carpool?

Count a move from home to work as one time and from work to home as well as once. Carpooling in the morning and in the evening is therefore 2 times carpooling.

Circle the correct number, one answer possible

---

1 one or more times a week

- 2 not every week, but one or more times a month
- 3 not every week or month, but one or more times a year

29. How many people do you usually carpool with (driver included)?

---

\_\_ Persons

Code 9 for Do not know

30. What is your personal total monthly net income on average?

Circle the correct number, one answer possible.

---

Your total monthly net income consists of:

- **net - professional earnings from work** (net wages, net business income);
- **net replacement income** (unemployment disability or invalidity allowances, subsistence minimum, OCMW support or pensions);
- additional net incomes (eg rental income)

Total net personal income:

- 1 0 – 1.000 € per month
- 2 1.001 – 1.500 € per month
- 3 1.501 – 2.000 € per month
- 4 2.001 – 2.500 € per month
- 5 2.501 – 3000 € per month
- 6 more than 3,000 € per month

31. What is your marital status?

Circle the correct number, one answer possible.

---

1 unmarried

2 married

3 separated

4 widow | widower

5 registered cohabiting (ENQ: d.i. cohabitation contract signed at the town hall)

THANKS FOR ANSWERING THESE QUESTIONS.





## APPENDIX 2: LIST OF THE PUBLICATIONS OF THE AUTHOR

### *A2.1 INTERNATIONAL JOURNALS WITH READING COMMITTEES*

- Samar EL-AMINE, Stéphane GALLAND, Abderrafiaa KOUKAM. "Agent-Based Modeling of Social Behavioral Challenges in Transportation." In International Journal of Ubiquitous Systems and Pervasive Networks (JUSPN), vol. 10(1), pp. 33-40, 2018.
- Fatma OUTAY, Absar-UI-Haque AHMAR, Faouzi KAMOUN, Ansar-UI-Haque YASAR, Christoph SOMMER, Nafaa JABEUR, Samar EL-AMINE. "Investigation of the impact of a wireless Fog Warning System with respect to road traffic on a highway." In International Journal of Personal and Ubiquitous Computing, vol. 1-7, rank: Q2, IF: 1.924, 2018.

### *A2.2 INTERNATIONAL CONFERENCES*

- Samar EL-AMINE, Stéphane GALLAND, Ansar-UI-Haque YASAR, Abderrafiaa KOUKAM. "Demand for Agent-Based Transportation Models & Social Behavioral Challenges." In Proc. of the 8th International Conference on Emerging Ubiquitous Systems and Pervasive Networks (EUSPN 2017), Lund, Sweden, Elsevier, 2017.
- Samar EL-AMINE, Stéphane GALLAND, Ansar-UI-Haque YASAR, Abderrafiaa KOUKAM. "Towards Agent Based Modeling for Mobility Behavior Shift." In Proc. of 7th International Symposium on Frontiers in Ambient and Mobile Systems (FAMS 2017), Springer, 2017.
- Fatma OUTAY, Faouzi KAMOUN, Ansar-UI-Haque YASAR, Elhadi SHAKSHUKI, Samar EL-AMINE. "ConVeh: Driving Safely into a Connected Future." In Proc. of Procedia Computer Science, pp. 460-465, volume 113, 2017.

### *A2.3 NATIONAL CONFERENCES*

- Samar EL-AMINE, Stéphane GALLAND, Ansar-UI-Haque YASAR, Abderrafiaa KOUKAM. "Demand for Agent-Based Transportation Models & Social Behavioral Challenges." In Proc. of FUTURMOB17 Workshop, Burgundy Franche-Comté University, Montbéliard, France, 2017.



## APPENDIX 3: RÉSUMÉ LONG EN FRANÇAIS

### A3.1 CONTEXTE ET PROBLÉMATIQUES

La congestion routière est depuis longtemps un sujet d'inquiétude au Liban. La disponibilité réduite des transports publics est considérée comme un facteur majeur dans celle-ci. La possession de véhicules a rapidement augmenté pour répondre à la pénurie de transport public (Macal et North, 2010). Les embouteillages causés par le recours intensif au transport privé ont non seulement entraîné la baisse de la fluidité des transports, mais ont également aggravé les risques pour l'environnement, en particulier la dégradation de la qualité de l'air causée par les émissions de gaz. Par conséquent, il est devenu nécessaire de promouvoir et de soutenir l'utilisation des transports en commun pour minimiser les congestions et l'impact sur l'environnement (Holmgren, et al., 2012).

Cette thèse porte sur la modélisation des comportements de déplacement, basée sur la modélisation orientée agent, et prenant en considération la situation socio-démographique de Beyrouth. La modélisation basée sur des agents est de plus en plus utilisée dans les sciences du transport. Elle permet de développer plus efficacement des outils de planification et de prévisions, comme les modèles de gestion des systèmes de transport urbain. La modélisation et la simulation basées sur les agents (ABMS) est une méthode de modélisation permettant la modélisation et la reproduction des activités des entités autonomes et de leurs interactions, tout en ayant pour objectif de mesurer l'impact sur le système (Ortuzar, Willumsen, 2011).

Un aspect important de l'analyse du fonctionnement des facteurs économiques et sociaux influant sur le choix du mode de transport à Beyrouth est la constatation d'hypothèses initiales qui déterminent le comportement de la catégorie clé des passagers dans le marché des transports à Beyrouth. Le comportement de mobilité des passagers est le principal facteur qui détermine les activités des entreprises de transport et des autres acteurs du marché. La fourniture de services dédiés n'est efficace que si le consommateur achète pour lui un ensemble de services marchands et le paie en temps voulu au prix actuel du marché (Crooks & Heppenstall, 2012).

#### A3.1.1 ÉTUDES ÉCONOMIQUES SUR LE COMPORTEMENT EN MATIÈRE DE TRANSPORT

De nombreuses études économiques montrent que les personnes ne sont pas en mesure de prendre des décisions optimales dans leur comportement économique dans certains cas de figure. L'un des premiers chercheurs sur le comportement irrationnel des individus était G. Simon, auteur de la théorie de la rationalité limitée. Selon lui, les agents économiques utilisent l'analyse heuristique plutôt que l'optimisation formelle. La plupart des situations de choix économique sont complexes et il est impossible de prendre en compte de manière précise l'utilité de chaque action. Par conséquent, les décisions prises peuvent être irrationnelles. La théorie du comportement du consommateur est étudiée par des économistes qui adhèrent à l'institutionnalisme et au néo-institutionnalisme (Crooks & Castle, 2012).

### A3.1.2 THÉORIE ÉCONOMIQUE CLASSIQUE

On suppose que les biens et services ne sont échangés directement ou avec de l'argent que si leur valeur est égale et que l'acheteur essaie toujours de minimiser leurs coûts. Pour les déplacements urbains des passagers, cela signifie que le passager doit utiliser le mode de déplacement qui a le coût minimum en rapport à la distance requise tout en offrant le confort de conduite et la qualité de transport souhaités (Crooks & Castle, 2012).

En réalité, ce choix n'existe pas : les passagers utilisent souvent les services d'un taxi ou d'une voiture personnelle, bien que le coût d'un voyage dans ce cas soit souvent des dizaines de fois supérieure au coût d'un voyage similaire dans les transports publics (Crooks & Castle, 2012). Ainsi, dans le cadre de la théorie classique, la principale contradiction pour la sphère des transports publics est l'écart important entre le coût du service de transport et son utilité pour un individu donné; actuellement, il n'y a pas d'explications théoriques sur la manière de surmonter cette contradiction.

### A3.1.3 LA THÉORIE ÉCONOMIQUE INSTITUTIONNELLE

Cette théorie explique le comportement des passagers. T. Veblen a exprimé des idées clés sur l'institutionnalisme il y a plus de 100 ans. La théorie institutionnelle développée dans les travaux de Commons, Mitchell, Pierce, etc. Le principe fondamental du concept d'institutionnalisme est que le fonctionnement des individus se produit dans un environnement spécifique formé par les institutions (McKerlich, Ives, McGreal, 2013). Une institution distincte signifie un ensemble de règles qui déterminent et réglementent les actions des entités économiques individuelles. Ces règles découlent des propriétés organisationnelles, nationales, sociales, culturelles, des qualités, des formes et des mécanismes de la société (Ghorbani et al., 2014).

L'économie de l'institutionnalisme repose sur l'hypothèse de l'adéquation possible d'une approche optimiste à l'étude du comportement humain, bien que ce ne soit pas le cas dans la plupart des cas. Dans de nombreux cas, le sujet n'effectue pas un calcul précis pour garantir l'efficacité maximale de son choix et s'appuie sur les traditions existantes, son expérience ou les habitudes acquises (Macal, 2016). La capacité de s'appuyer sur des règles institutionnelles simplifie le comportement des individus, même s'ils sont confrontés à des problèmes d'optimisation.

### A3.1.4 HABITUDES ET RÈGLES

Les habitudes forment le comportement habituel alors que les règles sont les instructions décrivant ce qui est permis et ce qui ne l'est pas. Les habitudes peuvent être innées ou acquises, et les règles conditionnelles ou inconditionnelles. Suivre des règles forme une habitude. Les règles sont généralement rompues plus facilement que les habitudes, car les habitudes prennent racine au niveau subconscient et ne se prêtent généralement pas à une analyse rationnelle. Ainsi, l'institutionnalisme fait écho aux théories biologiques du comportement économique, quand un individu se concentre sur l'optimisation de son choix. Avec un ensemble connu d'alternatives et une reprise de la sélection, il est possible d'utiliser des procédures simples pour trouver l'optimum en appliquant des solutions prêtes à l'emploi. Par conséquent, ce comportement peut être encore plus bénéfique que l'optimum calculé avec précision, car il permet d'économiser le temps et l'énergie de la personne qui prend les décisions. Par exemple, dans le domaine des transports publics, pour décider du mode de transport et de la route à suivre, le passager doit d'abord calculer l'efficacité des alternatives aux différents modes de déplacement et ensuite seulement faire son choix. Une manière plus naturelle de prendre une décision dans cette situation consiste à suivre les habitudes, par exemple, en utilisant le mode de transport proche du lieu de résidence. Une habitude similaire est inculquée au sujet par la répétition du choix initial. Le passager continuera à utiliser le mode de déplacement choisi, alors qu'un tel choix offre, de son point de vue, une efficacité satisfaisante. Dans des conditions de temps limitées,

l'individu ne peut pas traiter toutes les informations nécessaires au choix du mode de déplacement (Ascensão, et al., 2013).

L'agent autonome est une entité logicielle intelligente opérant pour le compte d'un propriétaire. En résumant de tels comportements, les économistes institutionnels soulignent que le fait même que les individus développent des règles et les suivent ne signifie pas qu'ils ne se comportent pas de manière rationnelle. On s'attend à ce que les règles s'appuient sur le caractère raisonnable et, par conséquent, l'utilisation des règles augmente l'utilité (Hamill, Gilbert, 2015).

Il existe également des exemples de développement de règles irrationnelles. Par exemple, les études de mobilité portant sur les facteurs de comportement économique et social affectant le choix du mode de transport à Beyrouth montrent que les mouvements sur les voitures particulières ont une part beaucoup plus importante que ce qui serait dû aux considérations économiques.

Our research focuses on the development of a model that describes passenger transport behavior in the urban transport system based on an institutional approach.

### *A3.2 OBJECTIFS DE LA THÈSE*

L'objet de la thèse est un modèle de simulation orienté agent du trafic routier en utilisant une approche économique institutionnelle. Nous proposons une architecture, des algorithmes et des méthodes pour implémenter le modèle des agents afin de modéliser et de reproduire leurs comportements de choix de modes de transport. Le but du travail est la création d'outils et de techniques qui garantissent l'utilisation de la simulation d'agents pour l'étude de schémas d'organisation du trafic. Pour atteindre cet objectif, les tâches suivantes ont été résolues dans le travail:

1. Comprendre les moyens de transport accessibles à Beyrouth et les présenter de manière simple et compréhensible.
2. Déterminer dans quelle mesure les facteurs économiques tels que les impératifs financiers, l'inflation croissante ont un impact sur le choix du mode de transport.
3. Mesurer le degré auquel des facteurs sociaux tels que le niveau de vie peuvent influencer le choix de l'homme dans le choix d'un mode de transport spécifique.
4. Examiner l'effet que des facteurs innés peuvent avoir sur une personne au fur et à mesure qu'il adopte un mode de transport spécifique.
5. Comprendre l'effet que le choix privilégié d'un mode de transport a sur le sort de la population à Beyrouth.
6. Créer un modèle de simulation orienté agent des usagers de la route pour Beyrouth.
7. Proposer une méthode permettant de simuler le comportement des usagers en cas de congestions ou d'événements survenant à Beyrouth.
8. Développer un progiciel implémentant le modèle d'agent proposé.

Les questions scientifiques associées sont :

1. Les facteurs économiques jouent-ils un rôle important lorsque les individus décident de choisir un mode de transport?
2. Les facteurs sociaux (installations, niveau de vie) jouent-ils un rôle décisif dans la décision des individus de choisir un mode de transport?

3. Les facteurs de carrière (salaire plus élevé, distance entre le domicile et le lieu de travail, emploi permanent / à temps partiel) jouent-ils un rôle moteur lorsque les individus décident de choisir un mode de transport?
4. Les facteurs du ménage (taille de la famille, revenu du ménage, âge des membres de la famille) jouent-ils un rôle moteur lorsque les individus prennent la décision de choisir un mode de transport?

### *A3.3 RÉSULTATS DES TRAVAUX DE RECHERCHE*

Nous avons analysé les données obtenues à partir d'une enquête que nous avons réalisé pour la ville de Beyrouth. Nous avons établi une relation l'emploi, le statut social et la sélection du mode de transport. L'attitude des usagers devient différente quand ils gagnent plus de revenus ou s'ils ont un statut supérieur dans le contexte de la gestion du trafic. Ils évitent les transports en commun et essaient d'utiliser leur propre moyen de transport privé.

La section suivante élabore des recommandations possibles pour les différentes parties prenantes impliquées dans notre étude.

#### *A3.3.1 VÉRIFICATION DES HYPOTHÈSES DE MODÉLISATION*

##### ***Hypothèse 1: L'emploi et le statut social ont un effet sur l'utilisation de la voiture en tant que conducteur.***

Dans les réponses aux questionnaires dans le cadre de notre étude, il a été constaté que les personnes employées ont tendance à utiliser l'automobile en tant que chauffeur près de 17 fois plus que les travailleurs indépendants. La possibilité pour un indépendant de posséder une voiture est de loin supérieure à celle du travailleur, mais la préférence pour l'utilisation de la voiture est moindre. Cela pourrait être dû au fait que de nombreuses organisations paient une indemnité de transport à leurs employés. En outre, la hausse des prix du carburant au Liban est également un motif de découragement et les travailleurs indépendants ont tendance à adopter une attitude de réduction des dépenses.

De même, plus le statut de la personne est élevé, plus elle est susceptible d'utiliser sa propre voiture en tant que conducteur. Cela s'explique par le fait que plus votre niveau social est élevé, plus votre emploi du temps devient flexible et, pour respecter ce calendrier, de nombreuses personnes choisissent d'utiliser leur propre voiture.

Ces résultats sont conformes aux résultats des recherches antérieures effectuées dans le même domaine (Nurdden , 2007; Hess, 2001; Garvill , 1999). L'attitude à l'égard des transports en commun a toujours été décourageante à Beyrouth. Les gens préfèrent généralement utiliser leur propre moyen de transport. Ceci est en partie due à la qualité des transports en commun et au problèmes dans le maintien des horaires. Par conséquent, les gens préfèrent utiliser leurs propres voitures pour les grands voyages, y compris ceux concernant les activités professionnelles.

Le statut social joue également un rôle relativement à la quantité d'argent gagnée par les individus. Ainsi, la tendance des plus hauts statuts à utiliser plus de leurs propres voitures est imputable au fait qu'ils ont plus d'argent à dépenser.

De plus, le gouvernement a créé des moyens pour simplifier l'acquisition d'une voiture et, par conséquent, davantage de personnes achètent des voitures pour elles-mêmes. Ceci a eu comme impact l'augmentation de l'usage des véhicules particuliers. De plus, si vous vivez dans des zones plus éloignées du centre-ville,

l'utilisation de votre propre voiture est plus facile et économique que le transport en commun et, par conséquent, les gens préfèrent avoir leur propre voiture.

***Hypothèse 2: L'emploi et le statut social ont un effet sur l'utilisation de la voiture en tant que passager.***

Il est impératif de comprendre le choix de l'utilisation de la voiture en tant que conducteur et passager. En général, les conducteurs sont embauchés en raison des longues distances, des déplacements excessifs, des problèmes de stationnement et du mauvais réseau routier. Par conséquent, les gens préfèrent être passagers dans le confort de leur voiture si et quand ils peuvent se le permettre.

Le fait de posséder une voiture est important. Cependant, si vous l'utilisez comme passager, c'est-à-dire avoir un chauffeur pour conduire la voiture, augmente votre statut dans l'organisation. Ainsi l'usage du véhicule en tant que passager a un impact sur le statut social.

***Hypothèse 3: L'emploi et le statut social ont un effet sur l'utilisation du bus.***

Dans notre étude, il a été constaté que l'emploi et le statut social peuvent contribuer à l'utilisation de l'autobus. Cependant, il ressort des données que le type d'emploi joue un rôle essentiel. Ainsi les travailleurs indépendants et les travailleurs n'utilisent pas beaucoup l'autobus. Cependant, il a été constaté que les personnes occupant d'autres professions sont plus susceptibles d'utiliser les autobus.

Nous avons constaté que les personnes qui travaillent dans des emplois où les salaires sont très bas et dont les moyens de transport personnels ne sont probablement pas utilisés finissent par utiliser des bus. Le comportement général de la population nous permet de constater que les bus ne sont pas très populaires dans la ville de Beyrouth.

***Hypothèse 4: L'emploi et le statut social ont un effet sur l'utilisation du service de taxi partagé.***

Les résultats de notre étude ont montré que nos deux facteurs contributifs; la profession et le statut social jouent un rôle important dans le choix du taxi partagé comme mode de transport. Cependant, les résultats ont également montré que le statut social prend une plus grande part que l'emploi dans l'utilisation des taxis partagés. Les congestions dans le trafic routier provoquent une augmentation des temps de trajet.

***Hypothèse 5 : L'emploi a un effet sur l'utilisation du mode de transport entre le lieu de travail/l'école et la résidence.***

Le moyen de transport utilisé pour se rendre au travail ou à l'école est généralement celui qui est le plus fiable, le plus efficace et le plus confortable. Le facteur de coût vient généralement plus tard. Toutefois, les résultats montrent que le moyen de transport le plus utilisé à Beyrouth est la voiture, suivi par les transports/bus scolaires. Nous pouvons voir d'après les résultats que le transport privé est préféré à Beyrouth par rapport aux transports publics. Cela donne également une image claire du faible usage des transports publics à Beyrouth.

### **A3.3.2 RÉSULTATS MAJEURS**

Les résultats de nos travaux montrent clairement que la profession et le statut social jouent un rôle dans le choix du transport. Cependant, leur rôle est différent. Afin de déterminer les facteurs d'une grande importance, nous avons tenu compte de diverses dimensions et de variables calculées. Nous pensons que la composition de l'échantillon joue également un rôle critique dans le type de résultats créés. Matsumoto et Vijver (2010) et Coyne (1997) ont également soutenu cet argument dans leurs recherches respectives. Par conséquent, une attention particulière a été accordée à cet aspect. Bien que les répondants de l'échantillon provenaient de différentes parties de Beyrouth et que les répondants ayant participé à l'étude aient été



choisis au hasard, l'échantillon était légèrement dominé par des personnes éduquées, employées et indépendantes.

Tout en analysant l'utilisation de la voiture en tant que conducteur, il a été observé que la profession et le statut de la direction jouent un rôle essentiel. On peut cependant constater que la profession prédomine dans la sélection des modes de transport plutôt que le statut social. Les résultats montrent que les personnes employées sont plus susceptibles d'utiliser la voiture comme conducteur que les personnes exerçant d'autres professions. Il a également été observé que les travailleurs indépendants utilisent les voitures 15 fois moins que les salariés. Cela pourrait être dû au fait que les personnes employées reçoivent une indemnité de transport et qu'elles ont davantage accès à des prêts auto que les travailleurs indépendants. En outre, les personnes employées voyagent généralement plus loin pour atteindre leur lieu de travail, tandis que les travailleurs indépendants travaillent à proximité de leur domicile. On a également constaté que la tendance à utiliser des voitures était très moindre chez les personnes occupant des emplois peu rémunérés. Nous pouvons voir que le salaire et les indemnités jouent un rôle clé dans l'utilisation de la voiture en tant que conducteur.

D'autre part, notre seconde observation est basée sur l'utilisation de la voiture en tant que passager. La partie du résultat sont similaires aux résultats précédents, à savoir que l'utilisation de la voiture est davantage le fait des employés. Cependant, pour l'utilisation de la voiture en tant que passager, le statut social joue un rôle plus important. Nos recherches ont laissé entendre que plus le statut de la direction est élevé, plus vous avez de chances d'utiliser la voiture en tant que passager et plus le statut de la direction est faible, moins vous risquez d'utiliser la voiture en tant que passager. Cela peut contribuer au fait que les personnes de niveau supérieur investissent plus d'énergie et de temps dans leur travail. La plupart des lieux de travail sont centralisés autour du centre-ville, loin des banlieues communautaires modernes. Les temps de trajet entre la maison et le lieu de travail sont donc importants.

De plus, nous avons observé à partir des données que la profession et le statut dans la gestion jouent également un rôle dans l'utilisation de l'autobus. Cependant, il a été constaté que l'occupation apporte plus de contribution que le statut. On a vu que les personnes occupant des «autres» professions dans les données ont une tendance à utiliser les bus. Cependant, on n'a pas vu que pour le reste des occupations, il n'y a pratiquement aucun usage du bus. On a également constaté qu'à tous les niveaux de la gestion, l'utilisation des bus est minime. Cela est dû au fait qu'il y a de grandes distances à parcourir à Beyrouth et que les bus avec leurs multiples arrêts rendent le trajet plus long et fastidieux. De plus, la ponctualité et la qualité du service de bus sont encore très limitées et les gens préfèrent donc utiliser d'autres modes de transport que les bus.

L'occupation et le statut social contribuent à la sélection des taxis comme mode de transport.

Cette recherche donne une image très claire du système de transport en commun de Beyrouth et peut aider grandement les analystes et les planificateurs à améliorer le système, et ainsi attirer les usagers dans les transports publics.

#### A.3.3.3 RECOMMANDATIONS

Comme le montrent nos résultats, la majorité des personnes utilisent leur propre moyen de transport. Cela rend automatiquement le « découragement du transport privé » l'étape la plus importante pour réduire la charge de la circulation et encourager l'utilisation des transports en commun. Afin d'aller dans ce sens, nous suggérerons :

Pour décourager l'utilisation des transports privés :

- Augmenter les prix des voitures ;
- Augmenter les taxes sur les voitures ;
- Introduire des péages et les augmenter chaque année ;
- Augmenter les prix de l'essence ;
- Introduire des redevances d'encombrement sur les routes principales ;
- Introduire des frais de stationnement dans le centre-ville.

Pour encourager l' utilisation des transports en commun :

- Améliorer la qualité du transport en commun ;
- Amélioré la disponibilité ;
- Amélioré la ponctualité ;
- Prix promotionnels de l'offre ;
- Augmenter la publicité aux futurs usagers.

### *A.3.4 PERSPECTIVES*

Cette section présente les perspectives de nos travaux de recherche. Les résultats obtenus sont intéressants et peuvent être utilisés par d'autres chercheurs. Cependant, il est important de mentionner qu'une importante limitation de notre étude concerne les questionnaires d'auto-évaluation utilisés pour la collecte des données. Le même questionnaire a été utilisé pour recueillir des données pour toutes les variables. Cela peut donner lieu à une «variance de méthode commune»; par conséquent, cette lacune devrait être fixée dans de futurs travaux.

Actuellement, nos travaux de recherche ont utilisé à la fois les sources de données et les résultats de recherche présentés dans un format de recherche de base. Néanmoins, l'étude peut également être menée dans d'autres formats. Elle peut se dérouler comme une étude de cas analysant différentes professions par exemple. Elle peut aussi prendre la forme d'une comparaison d'études réalisées dans plusieurs pays. Portant la méthode actuelle d'avance ou d'opter pour toute autre méthode, apportera plus de lumière sur l'étude.

Toute personne intéressée par cette étude devrait également envisager la diversification de l'échantillon de manière très critique. L'échantillon utilisé dans cette étude comporte des éléments de diversité, mais le nombre de personnes occupées et instruites est légèrement supérieur. Les futurs chercheurs devraient prendre des mesures pour former un échantillon relativement plus diversifié et neutre, ce qui les aidera à avoir une perspective plus claire dans tous les secteurs .

Les principaux aspects que nous abordons dans cette thèse sont l' analyse de la manière dont l'occupation et le statut de gestion du trafic jouent un rôle dans le choix du transport. En raison de certaines restrictions de l'étude en terme de temps et de coûts, les autorités locales de transport n'ont pas été impliquées. Ainsi l'intégration des professionnels du secteur des transports aurait amélioré la qualité des résultats de recherche.

## ABSTRACT

This research elaborates the importance of public transportation in urban cities like Beirut. Many studies have been used as reference that demonstrated the importance of public transport on public interest, for example by preserving the environment, reducing congestion and reducing the operational costs of transport in general. It highlights the current situation of public transportation in Lebanon and understanding people's choices in using different transportation tools during their daily movements. The research aim to identify and measure the parameters and causes that form the behavior of people and reflect their choices in the usage of miscellaneous road transport. Defining the parameters will help the decision makers to take actions for maximizing the usage of public transportation in the country.

This research displays a unique agent based behavioral model based on the socio demographic situation of the study region. The concept uses UML diagrams that explain the connections between agents and parameters. Agent-Based modeling has developed a vital factor for performing prediction-based scheduling, such as the transportation models for municipal cities. Agent Based Modeling and Simulation (ABMS) is a modeling method for aping the activities and connections of autonomous entities, with a vision of evaluating their impacts on the system all together. ABMS has been linked to a wide scope of spaces in transportation. These applications fundamentally fall into two procedural ideal models: individual-based models that analyse individual transportation-related movements and behaviour, and computational strategies that analyse a community oriented and receptive transportation outline that displays insight by representing a gathering of sovereign basic decision-making of subsystem materials called agents. Connections between the agents in the system are established, environmental variables are set, and simulations are run. The prior is decisively identified with the models for travellers' movements while the latter is usually examined as a computational plan in a distributed artificial intelligence (DAI) outline, or a complex adaptive system (CAS), which is a skilled procedure for imitating dynamic complex outlines to watch new performance. Not to forget the ideas recognised to the social behaviours in combination with the agent-based modelling procedures. OVG survey was conducted in Lebanon for data collection and Multinomial logistic regression was employed to analyze the data.

The major findings are elaborated from the data analysis. The research considered many factors and derived five major themes out of them i.e. car usage as driver, car usage as passenger, bus usage, taxi usage and work school transportation usage behavior. The research findings of the study clearly show that occupation and status in management play a role in the choice of transportation. However, their role different in the choice of transportation is different. To see which factors are of vital importance, we kept in mind various dimensions and computed variables that are more significant.

This research gives a very clear picture of the public transportation system of Beirut and can be of great help to analysts and planners in modifications in how to improve the system and to attract people in using more public transportation than private transportation.

## RÉSUMÉ

Au sein des environnements urbains et péri-urbains, le transport et la mobilité sont fortement liés aux activités socio-économiques. Ils sont influencés et affectés par la psychologie personnelle de chaque individu, les normes sociales, la résistance au changement, l'attitude personnelle, les habitudes, les peurs et les croyances. Ainsi, les individus constituant la population dans un environnement urbain choisissent d'utiliser les modes de transport durant leurs déplacements quotidiens en fonction de ces diverses influences. La mobilité et l'accessibilité aux lieux sont considérées comme essentielles pour mesurer la qualité de vie dans nos villes. Toutefois, il est communément admis que la topologie de nos villes possède une profonde influence sur cette mobilité et cette accessibilité. Cette thématique est au cœur de nos travaux de recherche. Ainsi, Beyrouth est une ville mono-centrique qui fait face à un problème de pauvreté de l'offre de transport. La possession de véhicules a rapidement augmenté pour répondre à la pénurie de transport public (Macal et North, 2010). Actuellement, il existe une opportunité de développer dans cette ville les services de gestion de la mobilité et d'y établir une mobilité et une accessibilité durables. La mobilité urbaine durable exige que les modes de transport soient abordables, efficaces et respectueux de l'environnement, avec une pollution atmosphérique et auditive minimale, ainsi que des technologies permettant de minimiser la consommation énergétique des moyens de transport. L'objectif de tels systèmes de gestion de la mobilité est de minimiser les coûts des déplacements. Cela est possible en mettant l'accent sur trois points principaux: réduire les besoins de déplacement, adopter des modes de transport plus respectueux de l'environnement et améliorer l'efficacité de la technologie et du transport des véhicules. De plus, cet objectif sera atteint en mettant l'accent sur l'accessibilité et non pas simplement en augmentant l'infrastructure routière. Cette thèse porte sur la modélisation des comportements de déplacement, basée sur la modélisation orientée agent, et prenant en considération la situation socio-démographique de Beyrouth. Nous avons analysé les données obtenues à partir d'une enquête que nous avons réalisée pour la ville de Beyrouth. Nous avons établi une relation l'emploi, le statut social et la sélection du mode de transport. L'attitude des usagers devient différente quand ils gagnent plus de revenus ou s'ils ont un statut supérieur dans le contexte de la gestion du trafic. Ils évitent les transports en commun et essaient d'utiliser leur propre moyen de transport privé. L'objet de la thèse est un modèle de simulation orienté agent du trafic routier en utilisant une approche économique institutionnelle. Nous proposons une architecture, des algorithmes et des méthodes pour implémenter le modèle des agents afin de modéliser et de reproduire leurs comportements de choix de modes de transport. Le but du travail est la création d'outils et de techniques qui garantissent l'utilisation de la simulation d'agents pour l'étude de schémas d'organisation du trafic. Pour atteindre cet objectif, les tâches suivantes ont été résolues dans le travail: i) Comprendre les moyens de transport accessibles à Beyrouth et les présenter de manière simple et compréhensible; ii) Déterminer dans quelle mesure les facteurs économiques tels que les impératifs financiers, l'inflation croissante ont un impact sur le choix du mode de transport; iii) Mesurer le degré auquel des facteurs sociaux tels que le niveau de vie peuvent influencer le choix de l'homme dans le choix d'un mode de transport spécifique; iv) Examiner l'effet que des facteurs innés peuvent avoir sur une personne au fur et à mesure qu'il adopte un mode de transport spécifique; v) Comprendre l'effet que le choix privilégié d'un mode de transport a sur le sort de la population à Beyrouth; vi) Créer un modèle de simulation orienté agent des usagers de la route pour Beyrouth; vii) Proposer une méthode permettant de simuler le comportement des usagers en cas de congestions ou d'événements survenant à Beyrouth; viii) Développer un progiciel implémentant le modèle d'agent proposé.