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ECONOMIC GROWTH IN LEBANON VIEWED THROUGH THE TRANSPORT SECTOR: A CASE STUDY OF THE POTENTIAL REVIVAL OF THE TRIPOLI-BEIRUT RAILWAY AS A WAY OF ADDRESSING THE PARADOX OF SUSTAINABLE DEVELOPMENT

by
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AN ABSTRACT OF THE THESIS OF

Dima Yehya Chatila for Master of Art
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Title: Economic Growth in Lebanon Viewed through the Transport Sector: A Case Study of the Potential Revival of the Tripoli-Beirut Railway as a Way of Addressing the Paradox of Sustainable Development

Transport is strongly linked to economic development by a complex set of opposite double-effect mechanisms and determinants. In Lebanon, a small developing country with rapid urban sprawl promoting auto dependency trends, huge negative externalities including congestion, accidents, air pollution, environmental noise and climate change estimated in our study at 3 Billion USD (7% of GDP forecast 2015) are generated by road transport. In this context, the revitalization of sustainable transport modes such as railway along the highly congested suburban corridors (i.e. Beirut-Jounieh-Tripoli) is examined as a potential mean to reduce the effect of these welfare losses and address the challenge of sustainable development. With these results we aspire to develop the notion of self-destructive economic growth, and to justify the urgent need to shift the current development paradigm, moving away from the traditional unconditional growth-oriented and all-else-equal models towards all-inclusive models of sustainable development.

CONTENTS

EQUATIONS

ILLUSTRATIONS

TABLES

ABBREVIATIONS

BAU: Business as Usual
CBA: Cost-Benefit Analysis
DALY: Disability-Adjusted Year
GBA: Greater Beirut Area
GHG: Greenhouse Gas
GWP: Global Warming Potential
HA: Highly Annoyed
HSD: Highly Sleep-Disturbed
LCC: Lebanese Community Corporation
LOS: Length of Stay
MAIS: Maximal Abbreviated Injury Score
MoPWT: Ministry of Public Works and Transport
OCFTC: Office des Chemins de Fer et des Transports en Commun
OR: Odds Ratio
PAH: Polycyclic Aromatic Hydrocarbons
PM: Particulate Matter
PPB: Part per Billion
PPM: Part per Million
ROW: Right-of -Way
RPTA: Railway and Public Transport Authority
SCC: Social Carbon Cost
TDMS: Transport Demand Management System
TT: Travel Time
VOC: Vehicle Operating Costs
VSL: Value of Statistical Life
WTP: Willingness to Pay
YOLL: Year of Life Lost

CHAPTER I

INTRODUCTION AND STUDY BACKGROUND

"Economics has traditionally been working with the abstraction of the point market in order to be able to focus on the processes of productivity growth and of general macroeconomic equilibrium. The insights of regional sciences on the one hand and of development economics on the other hand were generally ignored. Different methodical advances such as the treatment of economies of scale as internal to a model, respectively the question how a sustainable world economy could look like have lead economists to increasingly focus on questions of endogenous growth, of trade and therefore of transport. Transport quickly comes to the fore because the generalized costs of transport and travel still reduce the growth of the scale economies and because the external costs of transport significantly lower the welfare effects of that growth"

(Axhausen & Hell, 2007)

At the center of Solow-Swan neoclassical model of economic growth, the main assumption is that the decreasing productivity of capital leads to zero per capita growth in the long run, and only technological progress, which is assumed to be exogenous to the model, could affect growth over this period. Thus the steady-state Solow-Swan growth rate is determined by endogenous population growth and exogenous technological progress. For a more effective prediction of long-term per capita economic growth, this restrictive assumption was then substituted by endogenous models wherein long-term economic growth is determined by exogenous variables (including spatial and technology variables) within dynamic equilibrium framework settings. Today the analysis of all economic phenomena that interact with growth becomes indispensable as the examination of economic growth in isolation would be considered incomplete. Thus the present call is for a holistic economic growth theory in which not only rises in the steady-state growth rate but also major increases in the dynamic growth rate including social welfare are highly desirable(IFMO, 2007).

Among the economic phenomena that affect growth are the global development challenges relating to demographic growth, investment and technology, energy market prices, climate change and environment, land use patterns, urbanization and sprawl. These phenomena, which can be grouped under the wide umbrella of economic development, also lie, along with global macroeconomic impacts, at the core of the transport sector as well as the three dimension of sustainability: The economic sphere, the social sphere and the environmental sphere. In this context, the transportation industry analysis can be used as way to study the nature of dynamic economic growth and examine its level of sustainability.

In this context, our research addresses the dilemma of sustainable development and how the latter could be viewed through the window of the transport sector. It shows transport as a key element that could play a vital role in studying the nature of economic development, as well as solving the paradox of sustainable development (through a modal shift towards Railway Transportation) in a small developing country like Lebanon with its unique mix of socio-economic, geopolitical fluctuations and other particular features.

In the subsequent part of the introduction, our scope of work is presented, introduced by a brief literature review on Transport, Economic Growth and Sustainable Economic Development and their application to Lebanon, followed by a detailed description of the underlying mechanisms behind the multi-fold relationship between transportation and economic growth, as well as the mutual concerns of the transport sector and economic growth and development. These mutual concerns include, but are not limited to, mortality and morbidity rates from traffic accidents, delays in driver journeys due to traffic congestion, exposure to noise, air, soil and water pollution, as well as well multiple indirect impacts such as the negative effects of transport on urban areas, nature and landscape, up- and downstream processes, and energy dependency levels.

A. Transport, Economic Growth and Sustainable Economic Development: A Brief Literature Review

A detailed review of previous literature on Transport, Economic Growth and Sustainable Economic Development is beyond the scope of our paper. Nevertheless, it is recommended that the readers learn some insights from past research in this field where scholars have clearly explained the extent to which economics can contribute to urban transportation analysis and vice versa.

Different definitions of sustainability are used by different schools of economics. However, two primary clusters may be identified: (1) the ecological economics schools of thought and (2) the neoclassical environmental view (adopted in our study). While "both schools of thought share a conceptual definition of sustainability that is integrative in considering ecological, societal and economic dimensions" (DIW Berlin, 2006), core differences are identified, particularly in terms of perceiving growth and development.

On one hand, in the ecological definition of sustainability, societal value systems are viewed as an important element for a strategy of sustainability, and the concepts of growth (i.e. quantitative increase in size) and development (i.e. organizational improvement without change in size) are differentiated. Thus, while development may be sustainable, growth can't be indefinitely sustainable on a finite planet, and perceiving it as a goal per se can thus be questioned (Costanza & Daly, 1992). In addition, the umbrella of the ecological economics contains a larger number of research topics, “primarily related to social, distributional and evolutionary aspects of sustainable development as well as a strong microeconomic focus” (DIW Berlin, 2006).

On the other hand, in his paper on the “Nature of Economic Development and the Economic Development of Nature”, Environmental Economuist Partha Dasgupta showed that economic growth represents growth in prosperity (as the social worth of the full-range set of capital assets in an economy) rather than being restricted to only growth in GDP or contemporary ad hoc indicators of human development. Furthermore, the author defined sustainable development as “development in which wealth (per head) adjusted for its distribution does not decline” (Dasgupta, 2013). In other words, models of growth and development, lacking sustainability and thus ignoring spatial and social constraints, as well as environmental and other resource constraints, tend to be biased.

In the first part of our scope of work, we will demonstrate this conclusion but from a novel interdisciplinary perspective based on the analysis of the complex multi-fold causal relationship between transport and economic development. This interdisciplinary perspective is novel because in earlier studies on the relationship between transport and economic development, the main concern was to examine the direct impact of infrastructure (input variable) investment on growth (output) (IFMO, 2007). However, in our research we analyze the complex set of determinants, global concerns and underlying mechanisms behind the multi-fold causal relationship between transport and economic development, based on macroeconomic and microeconomic approaches, and on literature shedding light on some general aspects of this relationship.

On one hand, transport is viewed as a vital determinant of economic activity via trade competitiveness and efficient market access. In the introduction of their book on “the Economics of Urban Transportation”, Kenneth Small and Erik Verhoef qualified transportation as central to economic activity. The main reason behind this statement is the trade of intermediate and final goods and services, administrative functions and financial capacities, as well as expertise, technology with both private and public stakeholders. In fact, the trade of all these transactions, among others, lies at the core of today’s economic activity and requires at first place the transportation of people, goods and ideas (Small & Verhoef, 2007).

On the other hand, experts in the field of urban development view transportation and the way it might be negatively affected by economic development as a problem that is different from other challenges faced in developing countries, such as health and education. For instance, in his sourcebook on Sustainable Transport, Enrique Penalosa described how transport problems get worse rather than improve with economic development (Penalosa, 2005).

Therefore there are two wide-ranging contradictory effects of transport on the economy: today with globalization, transport systems become more and more vital for trade and economic competitiveness, and for enhancing the standards of living. Such potential positive effects lead to population and economic growth. The latter, if combined with a relatively unsustainable transport sector, may result in an exponential increase in demand for transport and related energy consumption, CO_2 emissions and other externalities generating high social costs.

Similarly, regarding the particularity of transport problems, one could understand from the note by the United Nations Conference on Trade and Development (UNCTAD) secretariat on “developing sustainable and resilient transport systems in view of emerging challenges” why transport is different from other sectors which may affect or be affected by the nature of economic development. This is mainly due to the fact that, while being “a determinant of efficient market access and trade competitiveness” leading to economic development, it has at the same time the “potential to erode some of its own benefits” (UNTCAD, 2014), and thus possibly eliminating an important part of economic welfare that it has initially generated.

According to a study done by CE Delft on total external costs of transport for 2008 by cost category in the EU-27 including Switzerland and Norway, the total external costs amount to EUR 514 billion (4% of this region’s GDP). While the most important cost category is accident costs representing 44% of the total external costs, climate change contributes to 29% and air pollution to 10% of these costs (CE Delft/INFRAS/Fraunhofer ISI, 2011). Also statistics from the U.S Energy Information Administration (EIA) about the World energy consumption by end-use sector and shares of total energy use in 2011 showed that among the4 major energy end-use sectors, transportation has the second-highest share of energy consumption (20%), following the industrial sector (EIA, 2014). Furthermore, statistics from the International Energy Agency (IEA) on global CO_2 emissions showed that the transport sector is responsible for 22% of global CO_2 emissions from fuel combustion in 2010 (EIA/OECD, 2013).

Such effects are widely seen in fast-pace small open developing countries like Lebanon where the increase in household real income is accompanied with a growing process of residential suburbanization, making a significant number of individuals depend on private car as their primary mode of transport. This trend of growing car dependency has numerous negative impacts such as those relating to traffic flow and air quality. In the context of this country, no exhaustive work has been done on studying the importance of the transport sector as (de)catalyst of economic development/growth. The existing literature is mainly based on spatial / geopolitical analysis with no real attention to economics. For instance, in his paper analyzing the transportation networks in Lebanon, Xavier Bernier qualified transportation as a key to Lebanon. He based his conclusion on geographical analysis and the historical role played by geopolitics in determining the processes of openness – closure generating the current superimposed transportation networks in Lebanon. As some of these networks have been destroyed / abandoned such as the rail lines, the country relies today on a complex roads network conjugated with a fluid infrastructure network. All these features, among others, make of Lebanon a fractured / fragmented territory (Bernier, 2010).

B. Mobility and Sustainable Economic Growth: Inextricable Twins?

1. *Transport and Economic Growth& Development: A Complex Multi-Fold Relationship*

a. <u>Transport and Economic Growth</u>

As specialization and growth require interdependency and market interaction, economic systems rely on the efficient and cost-effective trade of goods and services, within a commercial geography. Thus the study of economic systems necessitates the investigation of the spatial characteristics of transactions in terms of their basis, nature, origin and destination from both micro- (i.e. simple individual transactions) and macro- (i.e. complex network of national and international corporate transactions) perspectives. As all of these transactions involve moving people, freight and information, a close relationship exists between the sphere of exchange (i.e. the economic setting) and the sphere of mobility i.e. (the transport setting of movements(Rodrigue, Comtois, & Stack, Chapter 2 - Transportation Systems and Networks, 2006).

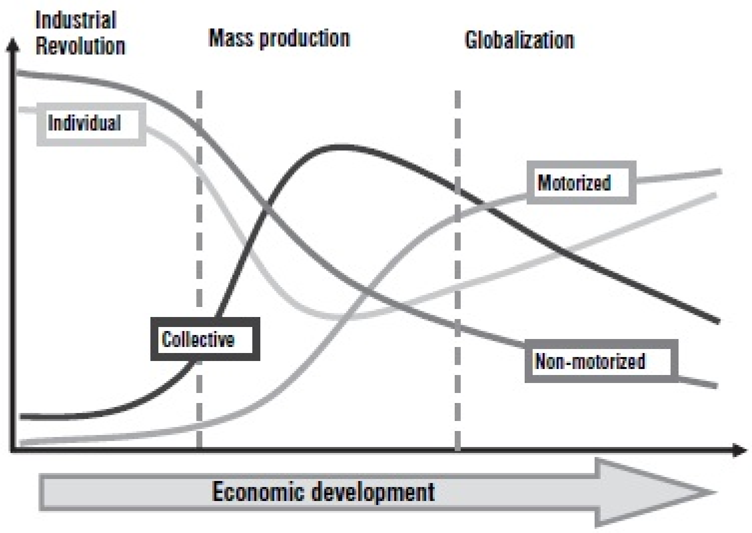
Today we are seeing rapid change in the way economic interactions take place. For instance, increasing globalization accompanied with decreasing trade barriers leads to a new perception of geo-economics and a massive increase in the trade of goods and services worldwide. Nations are required to enhance the efficiency of their transport sector in order to foster mobility and economic growth. This could be done through infrastructure investment and improvement. In this regards, it is crucial to note that as long as additional infrastructure is devoted to establish basic links in order to foster mobility, the necessity of infrastructure investment is not questioned (e.g. case of some developing countries where infrastructure supply is still at a very low level). However the economic impact of further infrastructure investment becomes controversial when well-connected transport infrastructure is already implemented (e.g. case of developed countries endowed with high mobility). On one hand, this is due to the fact that the law of decreasing marginal returns cannot be applied to transport infrastructure because of congestion which prevents the level of service from increasing with the total capital stock. On the other hand, the extent to which infrastructure investment affects economic growth highly depends on the demographic and economic characteristics of the investment region. Thus, the nature of the national economy as well as the different stakeholders and policy/decision makers in this local economy influence the magnitude of infrastructure investment impact on economic growth (IFMO, 2007).

In summary, distance can be viewed as a constraint to economic activity and thus to economic growth. However, if this constraint can be relaxed through transport system improvements, then it can be at the same time considered as a necessary condition to foster economic growth.

b. Transport and Economic Development

Among the fundamental features of economic activity is people, freight and information is mobility, as the latter satisfies the need to move between various locations. Furthermore, mobility lies at the core of the close relationship between transport systems and socio-economic changes, as it determines the levels of territorial accessibility. Thus mobility can be viewed as an indicator of development; while greater mobility may catalyze development, a low level of mobility may be an impediment for development. Moreover, economic development is highly associated with passenger mobility transition from non-motorized to motorized forms of transportation. The latter forms range from collective transportation to individual transportation that often prevails at a later development stage with the growth individual incomes (Rodrigue, Comtois, & Stack, Chapter 3 - Economic & Spatial Structure of Transport Systems, 2006). Figure 1 illustrates the association economic development and mobility transition.

Figure 1: Economic Development and Passenger Mobility Transition



Source: (Rodrigue, Comtois, & Stack, Chapter 2 - Transportation Systems and Networks, 2006)

However, it is worth noting that although deficiencies in transport services may constrain economic development, transport per se is not a sufficient condition for development. This issue lies at the core of complexity faced in establishing a formal relationship between transportation and economic development. Other drivers of this complexity may be (1) the time lag between economic development and transportation impacts, which renders difficult the recognition of the transport contributions to economic development; (2) the nature of transport impacts on economic development which range from benefits (i.e. promoting economic development) to costs (i.e. hindering economic development). Thus in most cases no direct linkages can be clearly established (Rodrigue, Comtois, & Stack, Chapter 3 - Economic & Spatial Structure of Transport Systems, 2006). Thus in order to measure the impact of transport infrastructure investments and transport sector improvements on economic development, it is important to establish a theoretical framework specifying the three central links between these two elements: (1) Investments in transport infrastructure alter the relative prices of accessibility to various locations, which leads to changes in the activity-based comparative advantage of the latter, and thus in the economic opportunities within these spatial locations; (2) infrastructure supply analysis is accompanied by transport economic behavior, which require a differentiation between the short and long terms. For instance, while infrastructure supply may only alter travel behavior (i.e. trip generation rate, traffic volume or choice of travel routes), it is more likely to affect firms' and households' localization decisions and thus to alter land and property prices in the long run; and (3) the benefits/losses from these alterations can be economically measured in terms of productivity and aggregate supply of and demand for input and output (IFMO, 2007).

2. Urban Transport and Sustainability

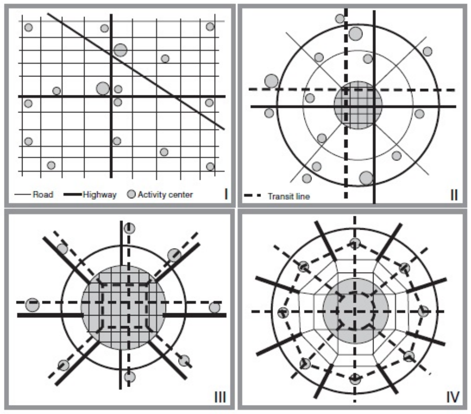
Urban transportation is comprised of three main categories: (1) Collective transportation which provides public accessibility/mobility to citizens and whose efficiency depends on capacity to move large numbers of passengers and to achieve economies of scale; (2) individual transportation including individual travel by automobile, walking, cycling and the motorcycle and whose efficiency depends on the city size and urban density; and (3) freight transportation including delivery trucks on roads, terminals as ports, railways and airports used for commercial activities (Rodrigue, Comtois, & Stack, Chapter 7 - Urban Transportation, 2006). In our study applied to Lebanon - a small open developing country – we exclude freight transportation as the latter requires a thorough separate study by itself.

Today we are seeing a rapid urbanization process expanded worldwide and accompanied with increased travel demand in urban areas. Urbanization as well as transportation trends, interact with the three spheres of sustainability. For instance, while a pure economic growth scenario promotes automobile travel culture, social and environmental scenarios promote public transit and travel substitutes such as telecommunication. Figure 7 in Appendix I illustrates the dynamic interaction between transportation trends and sustainability dimensions.

Four major metropolitan spatial structures are associated with the urbanization process, noting that these structures differ in terms of the degree of automobile dependency: (Type I) completely motorized network featuring automobile-dependent cities with limited centrality and low-to-average land use density. This type requires high-capacity highways and large parking spaces while public transit service plays a residual role in urban efficiency; (Type II) weak center featuring cities that emerged in the first half of the 20th century and that are characterized by concentric pattern and average land use density. This renders public transit systems under-utilized, unprofitable and thus subsidy-requiring. Also transit services are only provided along major congested corridors as it is not possible to serve the entire city with transit; (Type III) strong center featuring strategic commercial and financial cities with high levels of accessibility to urban transit and high land use density. The needs for high-capacity highways and parking lots are limited in the central district and urban efficiency is a major function of public transit; and (Type IV) traffic limitation featuring cities with public transit planning strategies, particularly in socialist economies with high land use density wherein automobile travel is planned to be limited in central area while promoted in peripheral zones(Rodrigue, Comtois, & Stack, Chapter 7 - Urban Transportation, 2006).

Figure 2illustrates the four main urban spatial types based on the nature of transport network.

Figure 2: Four main types of spatial urban structure depending on the nature of transport network



Source: (Rodrigue, Comtois, & Stack, Chapter 7 - Urban Transportation, 2006)

Regardless of the structure of spatial network, an urban transport system lacking sustainability and/or efficiency has negative socio-economic impacts such as congestion, accidents and mobility gaps, as well as other social and environmental loads generating unforeseen socio-economic consequences. The following are examples of the most important negative consequences of deficient transport systems. It is crucial to note that these consequences lie at the core of the three sustainability spheres (the Economic, Social and Environmental spheres):

- Mobility gaps including namely less travel cost affordability, higher travel time (TT), lack of resources and quasi- or complete inaccessibility. Such gaps may exist between different demographic, age, gender or income groups and prevail particularly in long-distance travel. We add to this the travel obstacles faced by pedestrians due to traffic intensity or inadequate infrastructure design/planning.

- Price differentials in goods and services, with higher prices confronted in less accessible locations, which hinder the competitiveness of the latter and thus limit economic opportunities of growth and development.
- Congestion experienced mainly in large urban agglomerations due to the increased use of transport systems (above design capacity). Congestion is associated with large market and non-market costs including but not limited to travel delays, discomfort & productivity loss and pollution. The main reasons underlying this problem are the failure of infrastructure supply to follow the rapid pace of demand for mobility, in addition to the growing auto dependency trend and under-utilization of public transit, which renders the latter services financially unsustainable.
- Accidents accompanied with the lack of safety measures taken while using transport modes, as well as inadequate and obsolete infrastructure. Accidents are generally proportional to the intensity of transport infrastructure use and tend to have socio-economic impacts including health damages, costs to insurance companies, property damage and productivity and life loss, with relative importance varying with the type of transport mode in use.
- Environmental noise generated by air, road and rail traffic circulation and negatively affecting urban population.
- Air pollution caused by atmospheric emissions from transport-related pollutants produced by the internal combustion engine. These pollutants such as volatile organic compounds, NO_x, CO and O_3 may cause respiratory and cardiovascular diseases.

- Land use and loss of public space due to increased traffic that has negative impacts on public activities and causes gradual loss of public space replaced by automobiles.
- Automobile dependency mainly driven by (1) underpricing of vehicle operating costs (VOC)which biases consumer choice towards auto use due to its affordability; and (2) public planning and funds allocated to road infrastructure investment and improvement such as increasing highway capacity and the number of parking lots at the cost of transit investments.
- Climate change exacerbated by the emission of transport-related pollutants causing nuisance to the atmosphere, including lead (Pb), carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NO_x), nitrous oxide (N_2O) and particulate matters (ash, dust) mainly from road transport.
- Biodiversity Loss associated with the use of construction materials and the expansion of land transport which negatively affect natural vegetation and cause deforestation and extinction of certain animal species. In addition, road maintenance and rail right-of-way (ROW) preservation need certain plants from growth in the subject areas.

(Rodrigue, Comtois, & Stack, Chapter 8 - Transportation and the Environment, 2006)

An example of the interaction between transportation and sustainability spheres is illustrated in Figure 7 in Appendix I.

C. Railway Transport: A Way to Address the Paradox of Sustainable Economic Development

Among the major considerations relating to trends in global economic and demographic growth, investment and technology, energy and transport costs, as well as climate change and environment, a topic that is highly debated today, especially between economists and sustainability experts, is the paradox of sustainable development. This paradox revolves around the question of how the needs of the present generations could ever be balanced with those of the future generations in a 3-dimensional sustainability perspective: environmental, economic, and social. In other words, while satisfying the increasing needs of today's populations may be viewed as an immediate necessity for their welfare, it may however jeopardize the wellbeing of future generations through the potential depletion of natural resources and the destruction of the ecosystem. The main reason underlying this dilemma is an entire architecture of contemporary unconditional growth-related development thinking (Dasgupta, 2013).

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Our scope of work includes the concretization of the relationship between transport and economic development, making use of the case of railway transportation as a potential key-element to addressing the paradox of sustainable development. This analysis will be also applied in the context of our study region – Lebanon. Our specific choice of transportation mode is based on existing literature showing its importance, not only in catalyzing economic development, but also in maximizing its sustainability level.

The CE Delft study on total external costs of transport showed that rail transport accounts for only 2% of external costs, while road transport is the least sustainable mode causing

93% of the total external costs (CE Delft/INFRAS/Fraunhofer ISI, 2011). In addition to social cost minimization, numerous economic benefits such as those relating to population and employment could be generated by rail transit, resulting from the access advantage provided by the vicinity areas. Furthermore, socioeconomic benefits may be generated from densification, as the latter could curb urban sprawl, generate higher revenues to governments and increase the employment opportunities for lower-income people who are transit dependent. Therefore, if these socioeconomic benefits resulting from rail transit-related economic development are large enough, they may offset or even exceed the external costs caused by railway transportation (Straszheim, 1979).

Given this importance of railway transportation in fostering economic development with minimal potential to erode any of its own benefits, compared to other modes of transport, and also due to its low cost compared to full underground metro rail, today developed countries are opting for the revitalization of urban light rail infrastructure (Crampton, 2003). For instance, in Lebanon we witness the potential revival of Tripoli – Beirut Railway. In 1891 a study was undertaken concerning the rail lines between Beirut and Damascus, and the line was opened in August 1895. Since this date, Lebanese railway transportation had operated well until the 1970s, period during which the concerned authorities failed at developing the related infrastructure in accordance with international standards. The internal lines became dysfunctional in 1975 while the coastline has ceased operation in 1990, mainly due to Lebanese war (Whiting, 2013). Today local & international experts and consultants regain interest in studying the potential economic development effects of this revival, after the European Investment Bank (EIB) put to tender the feasibility study of Tripoli-Beirut Railway revitalization project in November 9th, 2013, including technical, economic, financial, environmental, social and institutional aspects

(DEVEX, 2013). In our research, we will not only study the impacts of the revitalized urban rail infrastructure "on potential corridors of economic development along the new routes" (Crampton, 2003), but will also take the analysis a step further into viewing this potential revival as a way to solve the paradox of sustainable economic development.

Although rising environmental, social and economic concerns are not new, their cumulative negative impacts on living standards urge us today for a more meticulous study of their relationship: to what extent they are mutually exclusive, and how their convergence could play a role in reversing their negative impacts and fostering sustainable development patterns (Deakin, 2001).

In the subsequent sections of our research, we analyze the nature of economic growth/development in Lebanon from a passenger transport perspective. In Chapter II we present an overview of the road transport sector in Lebanon, and then propose a multiplistic[1] methodology to estimate the external costs of passenger mobility in Lebanon for 2015 as an approach for assessing the sustainability of economic growth in the country. The results of the estimation, as well as the discussion and limitations are presented last in the chapter. Chapter III opens with an overview of the rail sector in Lebanon followed by a brief case study of the potential revival of Tripoli-Beirut railway line as way to address the paradox of sustainable development. The study includes the estimation of the theoretical size of modal shift from automobile to rail based on a simplified elasticity approach, as well as a rough estimation of the potential reduction in road transport-related external costs should the rail service be implemented along the subject Northern suburban corridor. Chapter IV is the concluding chapter wherein the

[1]Multiplism is defined as the use of a multitude of data sources, research methodologies, theoretical perspectives and other components in order to address a policy question (MTI, 2014)

research objectives and results are summarized, and then a new paradigm shift toward smart-mobility economy and all-inclusive-growth-oriented transport policy is proposed.

Figure 6 in Appendix I illustrates the study framework of our research.

CHAPTER II

THE ECONOMIC DEVELOPMENT IN LEBANON VIEWED THROUGH THE PRISM OF MOBILITY

A. Road Transport Sector in Lebanon: An Overview

Today the transport system in Lebanon, with the associated negative externalities mainly in terms of lack of safety, travel time delays and air and noise pollution generated from the intense levels of traffic, is viewed as a major obstacle to achieving efficient urban structure necessary for the country and its potential to grow sustainably as a strategic touristic, financial and commercial hub.

In particular, the growing population accompanied with rising household incomes in the Greater Beirut Area (GBA),a modest-sized metropolitan area of nearly 1.5 million people, has resulted in a substantial outward expansion of the urban residents, following the trajectory of automobile-dependent sprawl evident in the GBA where passenger cars are the predominant mode of mobility. With high car ownership rate per household, and with a poorly performing public transport services, the net outcomes have been increased vehicle congestion, longer TT, increased travel distances. Higher traffic levels have resulted in increased motor vehicle emissions. In parallel, growth in transportation infrastructure has failed to keep pace with the rapid growth in population across the country, placing a strain on its current transportation system.

Compared to developed countries, Lebanon has a larger share of old vehicles generating higher proportionate emissions per vehicle-km especially during peak hours. In 2011, about 20% of greenhouse gas (GHG) emissions and 99% of CO emissions in Lebanon were released by the transport sector, and mainly passenger road transport which is viewed as the largest contributor to GHG transport emissions in Lebanon(MoE/gef/UNDP, 2011).

With a continuous quick paced demographic growth, the total population in Lebanon is expected to reach 5.2 million by 2026. This growth, associated with the rapid urbanization process, would lead to significant increase in demand for travel especially in urban and suburban areas, worsening congestion and increasing transport-related negative externalities. In this context, the average number of daily motorized trips per capita is expected to grow by 60% in 2026. In addition, under the present scenario of car price affordability through credit facilities associated with the existence of inefficient and unreliable collective/public transport systems, the share of passenger-car trips in the vehicle fleet is estimated to reach 90% in 2030with the same fuel types and related energy intensity (MoE/gef/UNDP, 2011).

This chapter illustrates the critical transportation challenges the country is facing today preventing economic growth from being sustainable, and thus elucidates the necessity of reversing this trend of automobile-dependent sprawl if significant headway is to be made in increasing the city's economic competitiveness and sustainable growth through energy- and time-efficiency improvements.

B. External Costs of Mobility: A Multiplistic Approach for Assessing the Sustainability of Economic Development in Lebanon

In this section, we aim at estimating the monetary value of the main external costs of transport in Lebanon. Due to lack of data available on the country level, our estimation is based on a multiplistic approach through which we compile recent academic and corporate research on road transport-related external costs with an aim to propose robust estimates.

The results could serve as a basis for comparing the external costs of various transport modes and conducting cost benefit analysis, as well as an important foundation for transport pricing and public policy making.

1. Methodology

With the lack of data from Lebanese national statistics, it is important to provide a robust methodology that is both scientific and consistent for monetizing the most important external costs of transport in the country. For this reason, as a basis for our methodology, we refer to the most recent study providing a comprehensive overview of the total, average and marginal external costs of transport in the EU-27 plus Norway and Switzerland in 2008, with the aim to get equivalent estimates for Lebanon for the year 2015.

The reference study was carried out by CE Delft, INFRAS and ISI under the supervision of the European Commission, and covered multiple cost categories including accidents, emissions (climate change, air, soil and water pollution, biodiversity loss), noise, congestion, as well as additional indirect external costs such as up- and downstream costs, urban effects, impacts on nature and landscape and energy dependency. These costs were assessed for both passenger and freight transport, taking into account a number of variables including all transport modes (i.e. Road Transport modes such as passenger cars, trucks, vans, two-wheelers, and buses, aviation, rail transport and inland shipping) except maritime shipping. The study also distinguished various transport network types (i.e. highways, motorways, expressways…), vehicle technologies and traffic situation and region types (metropolitan, urban, suburban, and rural).

Different cost category methodologies were used in the CE Delft study, and were mainly based on two previous state-of-the-art studies of the external costs of transport: Internalization Measures and Policies for All external Cost of Transport (IMPACT) and New Energy Externalities Developments for Sustainability (NEEDS).

The last updated IMPACT study was carried out in 2008 by CE Delft, INFRAS, Fraunhofer-ISI, University of Gdansk and IWW and resulted in three deliverables - a handbook and two reports.

The NEEDS project was undertaken by Charles University Environment Center (CUEC), University of Bath (UBATH) and Sweco Engineering & Design firm from 2004 till 2008 and provided a review of the methodology and practical Step-By-Step guidelines for applications in the Energy sector through a comprehensive Cost-benefit analysis (CBA). These reviewed guidelines represented a detailed CBA procedure, which was applied within the scope of the NEEDS study to energy production projects and their external costs as a practical guide for including environmental external costs of energy production in the economic analysis (CUEC/UBATH/Sweco, 2009).

Previous Union Internationale des Chemins De Fer (UIC) studies on external costs of transport (INFRAS/IWW, 2000) were also used by the CE Delft study, as they provided a comprehensive comparison of transport modes in Europe based on their economic impact on society(CE Delft/INFRAS/Fraunhofer ISI, 2011).

In our study, we aim at estimating the external costs of transport that are particularly relevant for addressing the nature of economic development in Lebanon. In order to obtain these estimates, input data including information on traffic accidents, transport-related emissions and traffic congestion are needed. Due to a lack of national statistics for certain cost categories, data from similar countries will be used and transferred to Lebanon using GDP/capita PPP differential with adjustment factors where needed. All costs obtained in monetary terms for previous years are transformed to 2015 USD values using estimates of the inflation rate in Lebanon. External costs are calculated for road transport, as rail modes are currently inexistent in Lebanon. A summary of the main macroeconomic development indicators used retained in our research is presented in Table 31 in Appendix I.

a. External Costs of Road Traffic Accidents

i. Overview

Today road traffic accidents represent the 8th leading cause of death worldwide: The approximate numbers of fatalities and injuries from road traffic accidents are estimated at 1.24 Million and 20 to 50 Million yearly (GRSP, 2013) and are expected to reach 2.16 Million and 33 to 82.5 Million, respectively, by 2020 (Choueiri, Choueiri, & Choueiri, 2010) and become the 5thleading cause of death worldwide by 2030 (GRSP, 2013).

The share of middle-income countries from road traffic deaths is 80%, with the Eastern Mediterranean countries accounting for the second highest number of fatalities per thousand (21.3 ‰) after Africa (GRSP, 2013).

High speed, not wearing seat-belt/helmet, drinking and driving, poor road quality, low vehicle standards and unenforced road traffic laws are considered as the key risk factors affecting road safety in the MENA region (GRSP, 2013).

In Lebanon, with a low-quality and poorly maintained road network, lack of traffic management and control, unenforced traffic laws and weakness in drivers' education, hundreds of people are killed on Lebanese roads each year. 25% of the fatalities are among pedestrians; this is mainly due to lack of sidewalks and crossing, and pedestrian law enforcement. Half of the accidents occur on undivided two-way urban roads, and 25% occur at night due to lack of proper road lighting systems. The highest share of traffic road crashes is for passenger cars (84%), followed by trucks (9%) and motorcycles (7%) (Choueiri, Choueiri, & Choueiri, 2010).

ii. Methodology for Calculating the External Costs of Road Traffic Accidents

The total social cost of accidents are the sum of the material damage costs (administrative costs, medical costs, production losses) and the immaterial costs (lifetime shortening, suffering, pain, sorrow …). While the material damage costs can be calculated using market prices (as they usually can be insured), the immaterial costs need other information (such as risk values through stated-preference studies) in order to be estimated. The share of external costs is separated from other accident costs by identifying the costs covered with insurance system transfers, and accounting for the anticipated risk costs (CE Delft/INFRAS/Fraunhofer ISI, 2011).

As a first-step adjustment, the latest official numbers reported road crash fatalities and injuries[2] provided by the Traffic Emergency Committee (TEC) at the Lebanese Interior Security Forces (ISF) and by Yasa association for road safety are adjusted for unreported accidents as illustrated in Table 1 below.

Table 1: Road accident cases in Lebanon (2010) by Province, Adjusted to Unreported Accidents

Province	Accidents	(n = 4583)	Injured	(n = 6517)	Killed	(n = 549)
	n	%	n	%	n	%
Mount Lebanon	1,958	43	2,827	43	238	43
Beirut	616	13	743	11	22	4
North Lebanon	668	15	920	14	102	19
Bekaa	723	16	1,069	16	117	21
South Lebanon	368	8	569	9	40	7
Nabatieh	250	5	389	6	30	5
TOTAL	**4,583**	**100**	**6,517**	**100**	**549**	**100**

Source: (IGSPS/WHO/MoPH, 2012)

[2] 360 fatalities and 4,154 injuries in 2010

A second-level adjustment to 2015 values is then made using population growth rates. Assuming that all road traffic crashes cause one or more types of injury, the differentiation of accident data is made as follows: 1% of the accidents are considered fatal, 33% causing major injuries and 66% causing minor injuries (Choueiri, Choueiri, & Choueiri, 2010). As no differentiation by the type of injury is made in the data collected and as the length of stay (LOS) at the hospital may be a reasonable proxy for injury severity when more detailed data are not available (Newgard, Fleischman, Choo, Ma, Hedges, & McConnell, 2010), Table 2 shows the expected LOS at the hospital depending on the maximal abbreviated injury severity (MAIS).

Table 2: Expected LOS per Injury Type

MAIS Category	Injury Type	AIS Score	Expected Median LOS (Days)
1	Slight Injuries	1 or 2	5
2	Moderate Injuries	3	10
3	Severe Injuries	4	17
4	Very Severe Injuries	5	12
5	Multiple Severe Injuries[3]	5 for the most injured organ, 5, 4 or 3 for the other(s)	39

Source: (Linn et al., 1993)

In Lebanon, around 82% of road crash injuries stay up to 5 days at the hospital, 9% spend 6 to 10 days and 9% need more than a10-day stay (Choueiri, Choueiri, & Choueiri, 2010).

[3] Those who are severely wounded in two or more body regions

The major external accident cost components (i.e. value of human life, human capital losses, medical care costs, and administrative costs including police costs and other insurance and administration costs) are considered in our analysis:

- The value of human life or the risk value representing the loss of utility of the victim, suffering of friends and relatives in case of fatality, and the pain and suffering of victims, friends and relatives in case of injury.
  A commonly comprehensive ex-ante approach used to estimate the external mortality costs is the willingness-to-pay (WTP) method based on the Value of Statistical Life (VSL) concept used to valuate human life in accordance with the estimated monetary value that individuals are willing to pay in order to reduce the risk of life loss to a minimum tolerable level. In this case, the risk value for fatalities is calculated as the monetary VSL generated from stated-preferences surveys to measure the individual WTP for a certain reduction of the accident risk (CE Delft/INFRAS/Fraunhofer ISI, 2011).This requires a trade-off for individuals between risk and economic resources which is measured in terms of the marginal rate of substitution of wealth for risk of death, a concept that is in accordance with the CBA fundamental principle of relating decision-making to the concerned agents' preferences (McMahon & Dahdah, 2010). However, estimating the WTP to prevent the loss of a statistical life (whether from road accidents or road emissions) requires technically sophisticated stated and revealed preference surveys to be designed in order to obtain accurate estimates of individual WTP for risk reduction. No such surveys have been carried out in Lebanon. For this reason, in our study, we use an alternative approach derived from the WTP method and

proposed by McMahon and Dahdah at the International Road Assessment Program. In this approach, the valuation of the statistical life in developing countries is based on the ratio of VSL to GDP per capita, assuming that the level income in a country is the primary factor for determining the VSL (McMahon & Dahdah, 2010). This "Rule of Thumb" approach consists of testing the relationship between VSL and GDP per capita through a log-linear regression analysis using a set of empirical data from over 20 countries from both the developed and developing worlds. Using the WTP equation[4] obtained by McMahon and Dahdah, we derive the estimated VSL in Lebanon based on historical data reported by the World Bank for the period from 2010 to 2015, as well as the International Monetary Fund (IMF) and the United Nations Development Program (UNDP) forecasts for the GDP and population growth rates, respectively for years 2014 and 2015. Table 3below shows the estimated yearly VSL in Lebanon for the period 2010-2015.

[4] $\log_n(VSL)=3.015+1.125x\log_n(GDP/capita)$

Table 3: Estimated VSL in Lebanon for years 2010 - 2015

Year	VSL (USD)
2010	555,243
2011	583,054
2012	627,675
2013	639,542
2014[f]	645,532
2015[f]	656,620

Source: Author's calculations

As for risk values for injuries, these are calculated based on the IMPACT Handbook (INFRAS/ISI/IWW/UG, 2008) numbers: 13% of VSL for severe injuries and 1% of VSL for slight injuries, in line with the CE Delft methodology. We also assume a mean rate of 7% of VSL for moderate injuries.

- Human capital losses include net production losses mainly due to reduced working time and replacement costs (CE Delft/INFRAS/Fraunhofer ISI, 2011) and can be presented in USD per Year of life lost ($/YOLL) or USD per day of life year lost ($/DALY).

  These net production losses are calculated in Equation 1according to the UNITE methodology:

Equation 1: Net Production Losses

Net Production Loss = gross production loss[5] - future consumption **(CE Delft/INFRAS/Fraunhofer ISI, 2011)**.

Net losses are considered to avoid double-counting of the lost consumption already included in the Risk Value.

For Lebanon, gross production loss per casualty is calculated as the average 2007 wage rate (Table 4) adjusted to 2015 value using inflation rate.

Assuming that an average household comprises of 4 members (CAS, 2012), the average expenditure for a Lebanese household is used to calculate the future consumption per individual (Table 5).

The average LOS at the hospital for road accidents' injuries is estimated at 1.76 days (Choueiri, Choueiri, & Choueiri, 2010).

Table 4: Average salary in Lebanon by economic sectors in 2007

Sector	Average Monthly Salary (000' LBP)
Agriculture	288
Manufacturing	569
Trade	578
Transport, Post & telecom	965
Services, Financial intermediation & Insurance	768
All Sectors (excluding construction)	**690**

Source: (CAS, 2011)

[5] Gross Production Loss = loss in future working time * average future national income/cap

Table 5: Average Annual Expenditure per Individual in Lebanon (by Product)

Product	Average Annual Expenditure per Individual (000' LBP)
Food and Beverages	1,710
Clothing and Footwear	416
Housing, Water, Electricity, Gas and Other Fuels	2,199
Furnishings, Household Equipment and Routine Household Maintenance	288
Health	603
Transportation	1,011
Communication	353
Recreation, Amusement and Culture	177
Education	452
Restaurants and Hotels	199
Miscellaneous Goods and Services	308
TOTAL	**7,715**

Source: (CAS, 2012)

- Medical care costs that are not covered by insurance: The medical costs are the external costs for medical care before the victim is deceased (in case of fatality) or until the person fully recovers (in case of injury) (CE Delft/INFRAS/Fraunhofer ISI, 2011).

The cost per stay at the hospital for road accidents' injuries is estimated at 600$ (Choueiri, Choueiri, & Choueiri, 2010). This value is adjusted to 2015 value using inflation rate.

Assuming that 52% of the total resident population in Lebanon do not benefit from any kind of health insurance (CAS, 2011), and that insured people are covered by the average proportion of 75% of hospitalization costs and consultation fees as a conservative estimate (Table 6), we obtain 2015 estimate for non-insured medical care costs.

Table 6: Medical Insurance Coverage by Different Insurance Programs in Lebanon

Medical Insurance Program	Health Coverage Size
National Social Security Fund (NSSF)	90% of hospitalization costs and 80% of consultation fees
Service Cooperative (CSC)	90% of hospitalization costs and 75% of consultation fees 75% of hospitalization costs and 50% of consultation fees
Security Forces (uniformed staff members): Army, Internal Security	100% of hospitalization costs and consultation fees for the staff member, 75% of the fees for the spouse and children and 50% for dependent parents
Ministry of Health (MOH)	85% of hospitalization costs and prescribed therapies in the private health sector for citizens not covered under any insurance plan
Private firms	Variable proportion of in- and out-patient care and pharmaceutical expenses per beneficiary

Source: (CDR, 2006)

- The administrative costs include the costs for police, and for justice and insurance administration, which are not carried by the transport users.

  As these costs may be insured against, market (shadow) prices can be used(CE Delft/INFRAS/Fraunhofer ISI, 2011).

  Due to the unavailability of data, administrative costs (i.e. the costs for police, and for justice and insurance administration not carried by the transport users) that are not covered by insurance are calculated referring to the average 2012 values for the United Kingdom (Table 7) from which we derive a best guess of 2012 values for Lebanon using GDP/capita PPP differential. The results are then adjusted using Lebanese inflation rate to obtain new estimates for 2015.

Table 7: Average Administrative Costs per Accident Severity (UK 2012)

Accident Severity	Administrative Cost Elements (GBP 2012)	
	Police Costs	Insurance and Administration Costs
Fatal	17,715	611
Serious	2,105	191
Slight	545	122

Source: (Department of Transport, 2012)

The cost of property damage is not included in the study because material damages are usually paid by the traffic participants through insurance premiums(CE Delft/INFRAS/Fraunhofer ISI, 2011).

b. <u>External Costs of Road Traffic Air Pollution</u>

i. Overview

Among the primary and secondary air pollutants caused by transport activities in Lebanon are particulate matters (PM_{10}, $PM_{2.5}$), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and ozone (O_3). Different categories of damages are caused by these pollutants, including human health (mortality and morbidity) damages, ecological losses and landscape degradation. Thus different types of external costs are generated from road transport-related air pollution. These include health costs due to cardiovascular/circulatory and respiratory diseases, building and material damages, crop losses and impacts on biodiversity and ecosystems.

ii. Methodology for Calculating the External Costs of Road Traffic Air Pollution

The costs accounted for in our study are health costs including mortality, respiratory diseases and cardiovascular diseases, net output losses as well as air degradation-related biodiversity losses:

- Health Costs: The health economic valuation is done by calculating the related air pollution cost factors (shadow prices) of each of these pollutants, including health costs, building and material damages, and crop losses.

  The bottom-up approach is used in the CE Delft study to calculate the external costs caused by transport-related air pollution based on the concentration-response relationship. In this approach, the calculation of damage costs is based on an impact-pathway method, which requires the following methodological steps: Emissions→transmission → concentration (dose) →impact/damage (humans, ecosystems, buildings)→ monetization → costs (calculated using emission data and unit cost factors) (CE Delft/INFRAS/Fraunhofer ISI, 2011).

Table 8 shows the average concentrations from these air pollutants related to transport activities in urban areas of Lebanon. With no mitigation measures in process, we assume that these average concentrations increase yearly at the annual population growth rate. We also assume that these average concentrations are specific to the GBA and can be generalized to all the country. For estimating the GBA population, we assume that one third of the Lebanese population lives in this area (Faour & Mhawej, 2014).

Table 8: Average Concentration Data for the Major Primary and Secondary Transport-Related Air Pollutant in Lebanon

Air Pollutant	Sampling Period	Location	Average Concentration
PM_{10} (µg/m^3)	2010	Urban areas	63
$PM_{2.5}$(µg/m^3)	2010	Urban areas	20
SO_2 (ppb)	2005	Beirut, Traffic	7.1
NO_2(µg/m^3)	2005	Beirut[6]	67
CO (ppm)	2004	Beirut (AUB Campus and Abdel Aziz Street)	2
O_3 (ppb)	2001	Beirut (AUB Campus)	45*

Sources: (ECODIT/MoE/UNDP, 2010), *(MoE/LEDO, 2001)

[6] Measured using a city-wide passive sampling network

Table 9 summarizes the concentration-response relationship values related to the main health damages (mortality and morbidity) resulting from six of the major air pollutants directly or indirectly caused by transport activities in Lebanon as reported by various public health studies.

Table 9: Summary of Health Impacts per 10 Units of air Pollutant

Pollutant	Mortality				Respiratory Admissions				Cardiovascular Admissions			
	(% change per 10 units pollutant)				(change per 10 units pollutant)				(change per 10 units pollutant)			
	range of estimates				range of estimates				range of estimates			
	Low	mean	high	Adj. mean	low	mean	high	Adj. mean	low	mean	high	Adj. mean
PM_{10} ($\mu g/m^3$)	0.4	0.8	1.1	0.4	0.7	2.1	3.5	1.2	0.5	1.4	2.3	0.8
$PM_{2.5}$ (μ/m^3)	1.7	2.88	4.5	1.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SO_2 (ppb)	0.8	2	3.9	1.2	1.3	3.7	6.1	2.2	0.2	1.1	2.1	0.6
NO_2 (ppb)	1.5	1.9	2.3	1.1	1	4.9	9	2.8	4.4	6.6	8.7	3.8
CO (1 ppm)	2	3.68	5	2.1	n/a	n/a	n/a	n/a	0.4	2	2.5	1.1
O_3 (ppb)	0.9	1.38	1.7	0.8	1.5	2.8	4.9	1.6	1.6	4.5	7.5	2.6

Source: (Sahsuvaroglu & Jerrett, 2003)

Since no comprehensive data on hospital admissions in Lebanon are available, we refer to the total Ministry of Public Health (MoPH) subsidized hospital admissions in year 2012 with a 11% of total admissions being respiratory admissions 13% being cardiovascular admissions (MoPH, 2012), using the MoPH subsidized admission rate of 27.3% (Sfeir, 2007). In addition, we assume that one third of the total admissions are distributed between public and private hospitals located in the GBA.

Table **10** shows the average hospital length of stay (LOS) for selected respiratory and circulatory/cardiovascular diseases, and the average hospitalization cost per stay provided by hospitals and insurance companies in Lebanon, based on 4,000 discharge forms for the given diagnoses codes in year 1998(METAP III, 1998). These codes are adjusted by GDP per capita in order to obtain 2010 values.

Table 10: Average LOS and Hospitalization Cost per Stay for Selected Respiratory and Circulatory Diseases

Selected Disease	Average LOS (Days)	Average Cost per Stay (USD 1998)
Chronic obstructive pulmonary diseases & allied conditions(ICD9: 490-496)	6.6	261.35
All pneumonias(ICD9: 480-486)	10	207.19
Acute respiratory conditions(ICD9: 464-466)	4.5	198.3
Ischemic heart disease & diseases of pulmonary circulation(ICD9: 410-417)	5.8	460.87

Source: (METAP III, 1998)

The above listed costs and LOS values result in average LOS of 7 days and 5.8 days for respiratory and circulatory and cardiovascular diseases respectively, and average costs per stay of 222.28 USD and 460.87 USD for respiratory and circulatory and cardiovascular diseases respectively. The latter costs are adjusted to 2010 and 2015 values using the annual inflation rate, and used as cost factors for valuing the excess morbidity from exposure to transport-related air pollutants.

Again, we assume that 52% of the total resident population in Lebanon do not benefit from any kind of health insurance (CAS, 2011), and that insured people are covered by the average proportion of 75% of hospitalization costs and consultation fee (Table 6).

The same VSL used for estimating the external cost of road crash fatality in 2010 is considered as cost factor for valuing the excess mortality from exposure to transport-related air pollutants (Table 3).

Based on the above data and assumptions, estimates for total external health cost of road transport-related air pollutants in Lebanon are obtained by multiplying each of the estimated number of excess fatalities, and respiratory & cardiovascular hospital admissions in the GBA by the corresponding cost factor for year 2010, and 2015 values are estimated using the annual inflation rate.

- The net output losses (economic losses associated with the death and hospitalization) are also computed multiplying the YOLL from restricted economic activity due to death or hospitalization days by the average annual wage used as a measure of the individual's productivity since no breakdown by gender, age, employment status and profession is available for the casualties.
- Biodiversity Losses: A part of the cost of biodiversity losses – those from airborne emissions leading to the eutrophication and acidification of natural ecosystems – is also added to the above-mentioned air pollutant costs. This cost is quantified using dose-response-functions that generate Potentially Disappeared Fraction (PDF) of species. The monetary valuation of PDF is calculated using a restoration cost approach used to quantify the restoration cost for the reconversion of land affected with acidification and eutrophication by NOx- and SOx-depositions to a natural state with high biodiversity. The results are cost factors for biodiversity losses due to airborne emissions from transport activities in USD/ton of air pollutant (CE Delft/INFRAS/Fraunhofer ISI, 2011).

Due to scarcity of data on biodiversity losses due to airborne emissions in Lebanon, we refer to the cost factors provided for Greece in 2009 (Table 11) and we transform the values to Lebanon using the GDP per capita differential between the two countries. These transformed cost factors are then adjusted to 2015 (using the annual inflation rate) and multiplied with the total emissions of NO_xandSO_x from transport activities in Lebanon.

Table 11: External cost Factors ofBiodiversity losses from airborne emissions deposited (EUR/kg) in Greece in 2009

Air Pollutant	Cost Factor (EUR/Kg)
NOx	2.21
SO_x	0.40

Source: (Walter Ott; econcept AG, 2009)

None of the above costs of health damage and biodiversity losses are allocated to the transport modes and vehicle categories given the major modal source of emissions is passenger cars dominating the vehicle fleet in Lebanon, and thus a modal allocation would be of small relevance.

Knowing that 60% of total oil consumption in Lebanon is related to transport activities, and that the energy dependency rates in the transport sector are 98.8% on gasoline and 1.2% on diesel (Mansour, 2012), we assume that these costs account for the external costs of up- and downstream processes related to transport activities such as the maintenance and disposal of vehicles (which is energy- and material- intensive and therefore leads to external costs such as climate change and air pollution costs).

c. External Costs of Climate Change

i. Overview

One most challenging global environmental phenomena today is climate change threatening ecosystems, food security, water resources, and thus sustainable economic growth. In this regards, the transportation sector, contributing to 22% of carbon emissions, is viewed as a main driver of global warming due to its intensive use of fossil fuels leading to GHG emissions. Road transport industry contributes to over 80% of carbon emissions mainly from private cars.

In this subsection we study the potential emissions reduction and social welfare losses resulting from GHG emissions in Lebanon, a small open developing country characterized by high car ownership rate, poor public transportation systems, and highest contribution of vehicle emissions to air pollution (Chalak, Al-Naghi, Irani, & Abou-Zeid, 2014).

ii. Methodology for Calculating the Social Costs of Climate Change

Two methodological approaches are often used for valuing climate change impacts:

- The avoidance cost approach is based on a cost-effectiveness analysis used to find the least costly option to achieve a required level of greenhouse gas (GHG) emission reduction. This target level is estimated sing a cost curve approach or other modeling methodologies (CE Delft/INFRAS/Fraunhofer ISI, 2011).
- The damage cost approach uses detailed models to combine the estimations of the physical impacts of climate change and those of their economic impacts. From a

(welfare) economic point of view for valuing the external costs of transport, this approach is preferred to the avoidance cost approach as it provides a direct measure and first-best estimation of the monetary value of the damages from transport externalities (CE Delft/INFRAS/Fraunhofer ISI, 2011).

In our study, we assume that effect of transport related emissions on climate change is relatively minor in a small country like Lebanon. Thus to simplify our computation, we estimate the social climate change costs from the major transport-related GHG (i.e. CO_2, CH_4 and N_2O), using the social carbon cost (SCC) in Lebanon valued at 17.44$/ton on average, estimated based on the carbon market price of mitigated GHG emissions in2010 (El-Fadel, Rachid, El-Samra, Bou Boutros, & Hashisho, 2013) as cost factor. To derive the external cost estimates, we multiply this factor by the total CO_2 equivalent GHG emissions using Global Warming Potentials (GWP) weights (Table 12) after estimating 2010 GHG emissions from transport assuming that, with no mitigation measures, these emissions increase with the annual population growth rate. The resulting total cost is then transformed to 2015 using the annual inflation rate in Lebanon.

Table 12: GHG Emissions from Transport Sector in Lebanon in year 2000 and their Related GWPs

GHG	Emissions (000' tons)*	GWP**
CO_2	3,929.4	1
CH_4	1.14	25
N_2O	0.03	298

Sources: *(MoE/gef/UNDP, 2011), **(CE Delft/INFRAS/Fraunhofer ISI, 2011)

d. External Costs of Road Traffic Environmental Noise

i. Overview

Noise emitted from all sources, except that accompanied with industrial activities, is defined as environmental noise. Although the latter has not yet been commonly recognized as a serious pollutant, it is a major environmental issue, especially that it may negatively affect exposed populations, generating health effects including cardiovascular diseases, cognitive impairment, sleep disturbance and tinnitus (WHO, 2012). Among the driving forces of environmental noise are urbanization, economic growth and motorized transport which increase the exposure to noise. Particularly, road traffic noise has been shown to increase the risk of high blood pressure and ischemic heart disease including myocardial infarction.

Road traffic noise is mainly derived from urban densification settings increasing the number of daily passenger trips. In Lebanon, inhabitants of urban areas reside and work under highly-disturbing environmental noise conditions, with dense old-engine traffic combined with excessive honking, generating extensive noise pollution mainly along urban road corridors.

For instance, according to a 1995 study, in Hamra street in Beirut, noise levels were found to be consistently above 90 dB(A) between 9 a.m.and to 2 p.m. during week days. Equivalent noise levels varied from 71.2 dB(A) at Hayek/Saloume to 82.0 dB(A) at Jal el Dib (CDR/TEAM International, 2000), values that exceed by far the noise limits set by the Ministry of Environment (Table 13).

Table 13: Lebanese ambient noise limits for intensity in different land use zones

Land Use	Noise Standard dB(A)	
	Day Time (7:00 a.m. to 6:00 p.m.)	Evening Time (6:00 p.m. to 10:00 p.m.)
Commercial, administrative, or downtown	55–65	50–60
Residential/commercial centers on highways	50–60	45–55
City residential areas	45–55	40–50
Suburbs with little traffic	40–50	35–45
Country residential areas, hospitals, parks	35–45	30–40
Heavy industries	60–70	55–65

Source: (MoE, 1996)

ii. Methodology for Calculating the External Costs of Road Traffic Noise

The following external costs of road-transport related environmental noise considered in our study: Sleep disturbance costs, annoyance costs, health damage costs and production losses. In order to estimate these costs, a quantitative risk assessment approach is used based on the identification of hazards, the assessment of population exposure and the determination of appropriate exposure–response relationships (WHO, 2012). This bottom-up approach comprises two steps(CE Delft/INFRAS/Fraunhofer ISI, 2011):

- Estimation of the number of people affected by road traffic noise, for noise levels above 55 dB(A)[7].
- Estimation of total noise costs by multiplying the number of people affected by the cost factor (i.e. noise costs per person exposed).

[7] For noise levels below 55 dB(A) it is assumed that no adverse effects on annoyance and health occur (CE Delft 2008)

Table 14 and Table 15 show the levels of noise tested in different locations in the GBA at various times of the day. Average levels are used in our estimation.

Table 14: Site characteristics and sound pressure level measurements in 14 sites in the GBA

Site	L_{den}[8][dB(A)]	Characteristics
Hamra	71	Shopping center, Universities, construction, high traffic
Mar Elias	69	Shopping center, traffic
Verdun	72	Shopping and amusement centers
Moulla	72	Construction, high population density, traffic
Tariq El Jdiade	78	Construction, high population density, University, high traffic, generators
Airport area	73	Airport sector, low traffic, construction
Chiyah	74	High population density, construction, high traffic, generators
Ras El Nabaa	69	Low population density, schools, low traffic
Achrfieh	69	Low population density, shopping, amusement center
Furn El Chebbak	79	High population density, construction, high traffic, generators
BourjHammoud	70	High population density, construction, high traffic
Antelias	72	Shopping center, high traffic
Mansouriye	65	Construction, low traffic, generators, rural like
Jall El Dib	69	Shopping center, generators, traffic

Source: (Korfali & Massoud, 2002)

[8] L_{den} is defined as the average equivalent sound level over a 24-hour period, with a penalty of 5 dB(A) added to the evening hours (19:00-22:00) and a penalty of 10 dB(A) added to the nighttime hours (22:00-7:00)

Table 15: Average Noise Levels at Various Locations in Beirut

Location	Average L_{day}[9] [dB(A)]	Average L_{night}[10] [dB(A)]
Saloume Intersection	69.2	46.2
Bliss Street	68.5	41.5
Mar Elias Street	72.5	70.7
Hamra Street	71.6	68.2
Dora Intersection	65.8	65.5

Source: (CDR/TEAM International, 2000)

Two general types of negative effects of environmental noise are distinguished:

- Costs of annoyance: Social disturbances from transport noise, resulting in social and economic costs (e.g. discomfort and restrictions on enjoyment of leisure activities…).

  The total costs of sleep disturbance and high-level annoyance for 2015 are included in our estimation of total external costs of road traffic noise in the GBA. The percentage of "highly sleep disturbed" persons (HSD) as a function L_{night} is calculated with the exposure–response relationship Equation 2 below:

Equation 2: Exposure–Response Relationship for Highly Sleep-Disturbed Persons due to Road traffic Noise

$$HSD\ \% = 20.8 - 1.05 L_{night} + 0.01486\ L^2_{night}$$ (WHO, 2012)

[9] L_{day} is the average level of noise (in dB(A)) during the daytime
[10] L_{night} is the average level of noise (in dB(A)) during the nighttime

The cost factor used in our sleep disturbance cost estimation is derived from the USD equivalent mean value of 8,750 CHF per person associated to the avoidance of noise-related sleep disturbance for year 2000 in Switzerland (SAEFL, 2003). This number is converted to it counter value in Lebanon using the GDP/capita PPP differential between the two countries, and to 2015 value using the GDP/Capita development in Lebanon.

The share of "highly annoyed" (HA) persons due to road traffic noise is calculated with the exposure–response relationship Equation 3:

Equation 3: Exposure–Response Relationship for Highly Annoyed Persons due to Road traffic Noise

$HA\ [\%] = 0.5118\ (L_{den} - 42) - 1.436 * 10^{-2} (L_{den} - 42)^2 + 9.868 * 10^{-4} (L_{den} - 42)^3$ (WHO, 2012)

For the cost factor used in our annoyance cost estimation, we refer to the value of 18 EUR used by the EU in 2013 as cost of reducing annoyance by 3db(A) for one person exposed per year (CEDR, 2013).

- Health damages: Resulting from high noise levels and generating medical costs, costs of productivity loss and costs of increased mortality rates (e.g. noise levels above 85 dB(A) can cause hearing damage, lower noise levels above 60 dB(A) increase the risk of cardiovascular diseases and may result in nervous stress reactions such as increase of blood pressure and hormonal changes).

In our estimation of the total external health damage cost of road traffic noise pollution in Lebanon for the year 2015, for the sake of simplicity, we only refer in our study to the numerical meta-analyses carried out to assess exposure–response relationships between environmental noise and cardiovascular risk, and to the external medical costs associated to the hospital cardiovascular admissions in the GBA.

The following polynomial odds ratio (OR) function fitted through the data points from the analytic studies within the noise range from 55 to 80 dB(A) is used in our analysis (see Equation 4 below):

Equation 4: exposure–response relationships between environmental noise and cardiovascular risk - Odds Ratio Function

$OR=1.63-6.13*10-4*Lday+7.36*10-6*L_{day}$ (WHO, 2012)

The data from Table 14 show an OR=1.59, which is greater than 1. This confirms the fact that exposure to environmental noise makes it more likely to develop the cardiovascular disease.

Based on this exposure-response function, we can obtain an estimate of the excess cardiovascular hospital admissions in the GBA. This number is then multiplied by the same cost per stay used in the estimation of road transport-related air pollution, assuming that the average LOS for cardiovascular cases is 5.8 days, and that 52% of the patients are not covered by insurance while the remaining 48% are covered at benefit from 75% coverage (CAS, 2011). We assume that the result can be generalized to reflect the total external health damage cost of road traffic noise pollution in Lebanon for year 2015.

e. External Costs of Road Traffic Congestion

i. Overview

Congestion may be caused by accidents, construction sites, inadequate weather and many other reasons. As a result of congestion, transport users experience increase in travel time, delays and unreliability, and operating costs. Congestion tolerance levels depend on many factors including the travel purpose, time and city size. In economic terms, congestion is described as the mutual disturbance, resulting in lower speeds of users competing for scarce capacity such as limited infrastructure-capacity on transport networks. Although it increases with traffic load, congestion occurs at all levels of demand even before full capacity limits are reached (CE Delft/INFRAS/Fraunhofer ISI, 2011).

Due to the intensive post-war development during the past 30 years, Lebanon has been facing a rapid growth in vehicle numbers, leading to severe delays and congestion especially in the urban road network (CDR, 2006). Today the demand for travel is quickly increasing, outpacing the adaptation ability of the country's transportation system. For instance, 2.8 million daily passenger automobile trips were made in the GBA in 2007. This number is expected to reach 5 million in 2015 (Chalak, Al-Naghi, Irani, & Abou-Zeid, 2014).

ii. Methodology for Calculating the External Costs of Road Traffic Congestion

Our estimation of the social costs of road traffic congestion in 2015 is based on the Technology Needs Assessment (TNA) study for Climate Change in Lebanon (MoE/UNEP/gef, 2012). In this study, the average cost of congestions for passenger cars in the GBA is calculated, given that this vehicle category accounts for the largest share of more than 80% from the total Lebanese vehicle fleet, and that the traffic in the GBA is highly congested compared to other areas of the country, with a stop time exceeding 15% of total travel time (MoE/UNEP/gef, 2012), and delays ranging from 5 to 30 minutes at some intersections. Table 16 shows the average social costs of congestions calculated for 1,247,572 passenger cars in the GBA using 2007 values of 1.2 passenger/vehicle as occupancy rate and 15,000 km as annual mileage (MoE/UNEP/gef, 2012).

Table 16: The Average External Congestion Costs in the GBA in 2007

Location/Driving Condition	Cost (cents/pass.km)
Peak Urban	6.73
Off-Peak Urban	1.04
Rural	0

Source: (MoE/UNEP/gef, 2012)

Based on the mean 2007 value of 3.885 cents/passenger km, we calculate the total social cost of road traffic congestion in the GBA for this year, using the number of passenger cars, the average occupancy rate (in passengers/vehicle) and the annual mileage 2007 (in km) to transform this average social cost (in cents/passenger km) to total social cost of congestion (in USD). We then convert the result to 2015 value using the inflation rate, and assuming that the number of passenger cars as well as the road traffic grow at 3% per year on average (CAS/MoE, 2006). We also assume that the 2015 estimate obtained can be generalized to all vehicle categories and to the whole country.

f. Other Non-Monetized Costs

In order to set the groundwork for future research and development , in this part we present a summary of other external Costs of transport that were not calculated in our study due to lack of data availability in Lebanon.

i. Costs for Nature and Landscape

The construction of transport infrastructure leads to land use change and habitat fragmentation. This again leads to natural ecosystem and biodiversity losses through the loss of natural habitats and habitat fragmentation. A repair cost approach (accounting only for transport infrastructure built after 1950) is used in the CE Delft study since there is no methodology for calculating the damage costs. Two cost elements were calculated within the study:

- Unsealing costs: These are the costs incurred when the area of transport infrastructure has to be unsealed in order to repair and compensate its damages to nature and landscape.

- Restoration costs of target biotopes/ecosystems: These are the costs of restoration of the unsealed area and additional impaired area along transport infrastructure in a way that the initial ecosystem (biotope) is re-installed.

Data on the area (e.g. length and width of the road infrastructure) are needed to estimate the costs to nature and landscape. The sealed area of road infrastructure can be calculated based on the infrastructure length and assumptions made about the average width of the different infrastructure types. A study of the ecosystem (biotope) in Lebanon, as well as data on the area (e.g. length and width of the road transport infrastructure), are needed to estimate these costs.

ii. Additional Costs in Urban Areas

Motorized traffic in urban areas has indirect effects on non-motorized traffic participants such as pedestrians and cyclists. The indirect external costs of time losses for pedestrians due to separation effects at traffic lights, crossings or railway crossing gates are measured in the CE Delft study. Information is needed on Detailed measures of road levels and crossings, the number of road crossings per person and day (by road and rail type: breadth, number of lanes/tracks), Average time loss per crossing and urban population(CE Delft/INFRAS/Fraunhofer ISI, 2011).

iii. Soil and Water Pollution

The most important negative effects of transport on soil and water quality emerge from the emission of heavy metals and polycyclic aromatic hydrocarbons (PAH) resulting in potential costs like plant damage, decreased soil fertility, pollution of drinking water, and wildlife habitat damages.

Due to the complex relationship between infrastructure use and soil and water pollution, a second best approach (based on the repair cost approach) can be used in to estimate these damage costs(CE Delft/INFRAS/Fraunhofer ISI, 2011). The following two steps are required in this approach:

- Estimation of the total land volume harmed by the water and soil pollution, assuming that the area harmed by these kinds of pollutions is equal to the area needed for the transport infrastructure and 5 m on both sides of the infrastructure. The total soil volume harmed thus calculated assuming that the depth of pollution is 20 cm.
- Estimation of the costs of soil and water pollution by multiplying the total land area harmed by an external cost factor expressed in USD/m^3. The total emissions of heavy metals and PAH can be calculated using emission factors per vehicle category multiplied by the corresponding mileage data.

iv. Cost of Energy Dependency (or Security of Energy Supply)

The unequal distribution of oil and fossil fuels leads to external costs of transport from dependency on oil producing countries. The economic costs of oil dependency (i.e. in % of GDP) are assessed by various studies. However, only few studies mention the direct link of oil dependency external costs to transport costs. The two major costs mentioned in CE Delft study were the economic losses as a result of oil prices that are higher than the competitive market level, and the costs of oil supply disruptions. The estimation of these costs requires information on the variance between oil prices and competitive market levels, and on oil supply disturbances.

2. Results, Discussion and Limitations

Following an application of the above proposed multiplistic methodology, Table 17is a summary of the external results for the different cost categories estimated for Lebanon for 2015, based on the data compiled and taking into account all assumptions, limitations and uncertainties reported in our study.

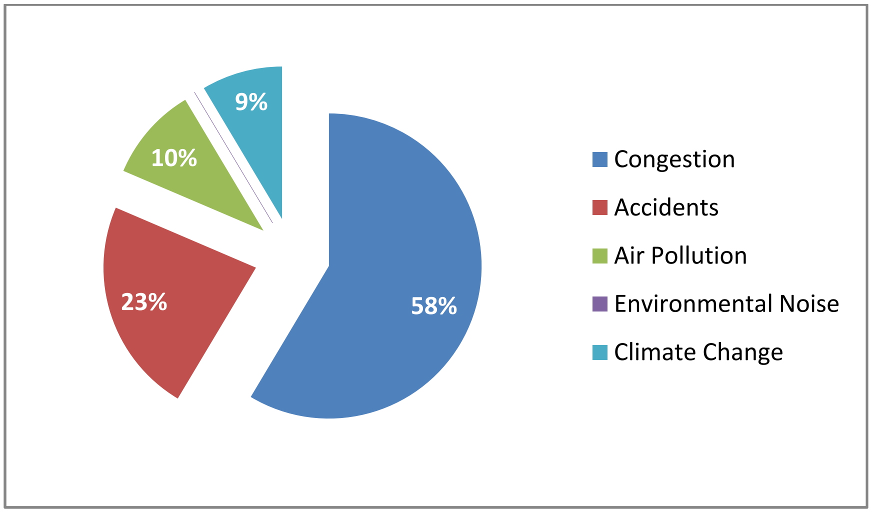
Table 17: Summary of Transport-Related External Costs on Lebanese Roads in 2015

Cost Category	Value 2015[f] (in '000 USD)	% from Total Costs	% from GDP
Accidents	767,910	23%	1.7%
Air Pollution	499,508	15%	1.1%
Climate Change	115,868	3%	0.3%
Environmental Noise	445,641	13%	1.0%
Congestion	1,493,535	45%	3.2%
TOTAL	**3,322,462**	**100%**	**7.2%**

Source: Author's Calculations

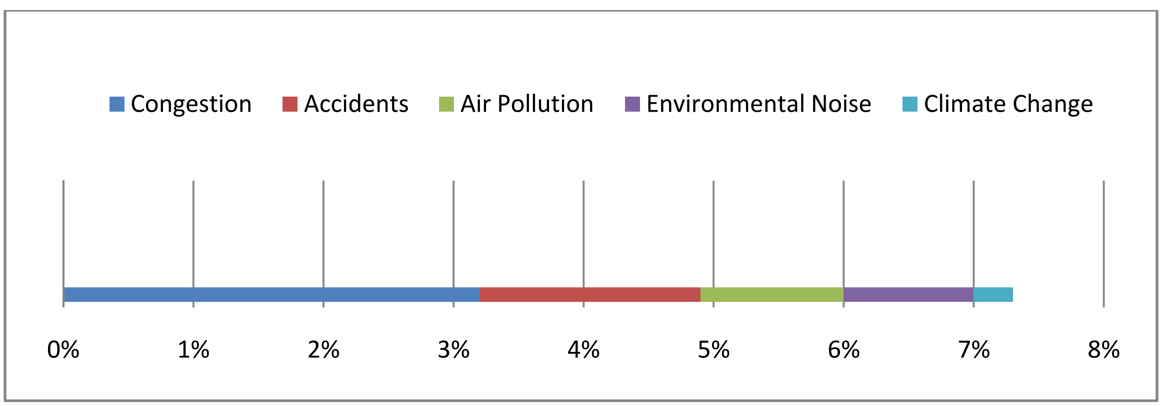
Figure 3 and Figure 4 respectively show the shares of each of the examined cost categories from the total external costs and from the GDP in Lebanon estimated at 46.2 Billion USD in year 2015 (The World Bank Data).

Figure 3: Respective share of each cost category from total estimated external costs for year 2015



Source: Author's Calculations

Figure 4: Respective shares of the different cost categories from the GDP



Source: Author's Calculations

By the end of 2015, the annual external costs of road transport in Lebanon are expected to reach about 3.3 Billion USD or 7.2% of GDP 2015[f]. Congestion costs are the major contributors to these externalities, accounting alone for 3.2% of the GDP and nearly half of the total costs. However, as the estimated SCC is relatively low given the small size of the country, climate change costs account for the lowest share from total costs (3%) and for only 0.3% of the GDP.

The estimated negative externalities of road transport significantly lower the welfare effects of economic growth and thus prevent it from being sustainable.

It is crucial to note that without action to prevent the urban population in Lebanon from following this path of automobile-dependent sprawl. In this context, in the subsequent chapter of our study we examine the theoretical potential gain in welfare from road transport, should an alternative to auto travel (i.e. railway service) have been implemented along the highly congested Northern suburban corridor in Lebanon.

A general major limitation in our proposed estimation methodology lives in the difficulty of data collection process due to a lack of up-to-date comprehensive nationwide statistics.

Another limitation in our study is the exclusion of the effect of the Syrian Crisis exacerbating the road transport-related external costs, given that the phenomena is considered as exceptional and may not continue over a relatively long period. However, recent research conducted by the UNDP showed that the increasing influx of Syrian refugees in Lebanon is expected to increase the emissions of air pollutants by 20%, which may lead to a further degradation of air quality in the country, mainly generated from road transport (Byblos Bank S.A.L - Economic Research & Analyis Dpt., 2014). In terms of land use and ecosystems, the study also indicated that the presence of the refugees increase the Lebanese population density by about 37% (Byblos Bank S.A.L - Economic Research & Analyis Dpt., 2014). However, in our study we refer to road traffic noise in the GBA since noise data are not usually reported for agglomerations below 250,000 inhabitants (CE Delft/INFRAS/Fraunhofer ISI, 2011). In 2001, the average population density in the GBA was approximately 6,200 inhabitants per km^2(Faour & Mhawej, 2014). Today due to the Syrian crisis, as the influx of Syrian refugees increased Lebanon's population density,a high urban densification level (i.e. in the GBA) would result in more vehicles on roads and thus exacerbate road transport-related negative externalities in Lebanon(Lebanon Star Newspaper, 2004).

Other particular limitations related to different cost categories are briefly stated as follows:

- Accident Costs: Recent research suggests that the LOS at the hospital may not be a stable proxy for estimating the level of severity for injuries, with the LOS statistics varying over time (OECD/ITF, 2009).

Environmental Noise Costs: Since there is no breakdown of total vehicle kilometers per mode and vehicle class in Lebanon, the total noise costs were not allocated to the various transport modes. However, it would be of interest to present the noise weighting factors for future research purposes (

- Table 18).

Table 18: Urban Noise Weighting Factors for Different Vehicle Classes (for average speed 50 km/h)

Vehicle Type	Noise Weighting Factor
Road	
Passenger car petrol	1
Passenger car diesel	1.2
Passenger car LPG	1
Moped	9.8
Motorcycle	13.2
Bus	9.8
Van	1.5
HDV solo < 12 ton GVW	9.8
HDV solo > 12 ton GVW	13.2
HDV with trailer	16.6
Rail	
Passenger train	1
Freight train	4

Source: (CE Delft/INFRAS/Fraunhofer ISI, 2011)

At the end, it is crucial to note that our estimation methodology can only be applied as long as the assumptions, limitations and uncertainties reported in our study are carefully taken into account.

CHAPTER III

THE POTENTIAL REVIVAL OF THE TRIPOLI-BEIRUT RAILWAY: A KEY TO STIMULATE SUSTAINABLE ECONOMIC GROWTH IN LEBANON

A. The Railway Sector in Lebanon: An Overview

1. The Abandoned Railways

The first railway in Lebanon was constructed during the Ottoman Empire period, with a concession to the French-established Société des Chemins de Fer Ottomans économiques de Beyrouth-Damas-Hauran in 1891. The earliest Railway line was the 1.05-m gauge Tramway Libanais (Beirut-Damascus) whose construction inaugurated in 1895 reached Maameltein in 1908. In 1942 British forces completed a standard gauge line to Tripoli as part of the Haifa-Beirut-Tripoli (HBT) line. Following the country's independence, the management and control of the parts of this rail system existing within the Lebanese territory were designated to Chemin de Fer de l'EtatLibanais (CEL). However, after the Lebanese Civil War, the rail network and services gradually ceased operation in mid-70's due to major damage. The last passenger rail operations ceased in the early 90's while the last freight rail operations were made to transport cement from Chekka to Beirut and stopped in 1997 (Al Mashriq, 2009). More details on the history of Lebanese railways are presented in Figure 8 in Appendix I

Today railway service is inexistent in Lebanon and the railroad is abandoned. In addition, the existent rail infrastructure is highly defunct, and many parts of the railway ROW have been either encroached upon by buildings or converted to freeways. However, the administration of railways continues to exist in the form of the Office des Chemins de Fer et des Transports en Commun (OCFTC) initially created in 1961 and currently reporting to the Ministry of Public Works and Transport (MoPWT) (CDR, 2006). In addition, the Lebanese State Railways (LSR) is the institution designated to protect the ROW from violations. Although it possess 90 million m^2 of Lebanese land, this institution operates with financial loss, with quasi-absence of operating revenue and about 600 salaried workers (Maalouf, 2010). The number of railway passengers in Lebanon between 1961 and 1970, as well as a thorough presentation of the present status of railway sector in Lebanon are presented in Table 32 and Table 33 respectively in Appendix I.

2. Railway Revival

A large number of proposals for reviving the Lebanese railway system have been prepared by national, regional and multinational consultants, but no project has been put into action to date.

Regional resolutions on railway development across all Arab countries were passed during the Arab league meeting in 1999. Following this meeting, Syria, Iraq, Jordan, Egypt and the GCC have started to execute their national railway development plans. However, no action has been taken in Lebanon due to the complexity of an eventual railway revival project. Similarly, in 2004 Syria and Lebanon examined the possibility 2 rail tracks from the old Beirut-

Damascus system, but no further action was taken due to regional geopolitical tensions. The most recent call for railway revival was launched in August 2013 when the European Investment Bank (EIB) put to tender the feasibility study of the potential reconstruction of the old Beirut-Tripoli railway in Lebanon, including the technical, economic, financial, environmental and social aspects of building the new line (Sponge, 2013).

It should be noted that the railway service in Lebanon requires as a first step an urgent focus on the highly-congested corridors (e.g. the Suburban Northeastern Corridor Tripoli-Jounieh-Beirut) in order to maximize the system cost effectiveness. However, as previously stated, no service could operate without a full preservation of the ROW along this corridor. However, the cost for preserving the ROW was estimated at 650 Million USD needed for land expropriation in 2006, in addition to the initial investment cost of 200 Million USD for implementing the railroad project. (CDR, 2006).

Therefore due to the project complexity and multi-dimensional barriers including the high implementation costs, a multi-stage revitalization process was recommended by consultants. For instance, in the first phase of the feasibility study of Beirut Suburban Mass Transit conducted in 2003 by DMJM, Harris International and IBI Group, the immediate implementation of commuter rail with later expansion to a full coastal railway was proposed as one of the multi-stage options. Other options involved the implementation of a bus rapid transit in the short-to-medium run before transition to rail one the challenges including the reclamation of ROW rights are overcome (DMJM/Harris International/IBI Group, 2003).

In the next subsection, we proposed a simplified approach to simulate the reduction in road transport-related welfare loss due to the potential revival of the Tripoli-Beirut Railway. Figure 9 in Appendix I shows the map of the Lebanese Territory including the study area.

B. Theoretical Potential Reduction of External Costs of Road Transport from the Revitalization of the Railway System

1. Simulation of Passenger Road-to-Rail Modal Shift Potential in Lebanon: An Elasticity-Based Approach

The planning process for rail systems usually involves the expectation of increase in rail mode share by attracting the following types of ridership demand: (Type 1) Modal shift demand, (Type 2) induced/generated demand and (Type 3) complementary demand.

Diverted demand (Type 1) is created when passengers of other transport modes choose to shift to rail transport, and thus involves competition with other modes. Induced demand (Type 2) is created when new passengers who do not use any of the alternative modes choose to travel by rail once the system is implemented. Induced traffic contributes to increase rail modal share but do not involve competition with other modes of transport. As for the complementary demand (Type 3), the latter is created when passengers use rail service as intermediate mode of transport, with aim to reconnect to another mode. This is the case when travelers use rail to connect to air flights. As this would increase both rail and air travel demand, it does not involve competition between the two modes (MTI, 2014).

In our estimation of the potential size of rail mode share in Lebanon should the new rail service be implemented between Tripoli and Beirut, we focus primarily on the potential road-to-rail modal shift, as the latter makes the greater share of the total demand for rail transport. A further focus in our study is the potential strength of competition between rail and passenger cars given that the latter constitute the highest share of the Lebanese vehicle fleet and thus contribute most increasing the external costs from road transport.

Both the induced and complementary demand are beyond the scope of our study, as none of these is directly associated to the potential reduction of the current transport-related external costs on Lebanese roads.

The identification and measurement of the potential ability of rail transport to attract ridership from auto-to-rail modal shift is critical and complicated; especially that rail service in Lebanon has been quasi-absent since the 70's and non-existent since the early 90's. However, it is clear that rail transport would strongly compete with passenger cars as it may constitute the optimal alternative for the users of passenger cars seeking to minimize their travel time and cost. Although little research has been conducted on direct competition between rail and passenger cars, theory and practice converge to the same broad conclusion stating that new rail systems, when implemented and managed properly along highly congested corridors are likely to result in significantly fewer motorized trip and thus leading to substantial shares of modal shift over short and long periods.

The objective of our case study is to estimate the extent of decrease of the current transport-related external costs on Lebanese roads should the Tripoli-Beirut rail line be implemented, and should passengers shift from car to rail. For this reason, it is important to examine the expected size of the modal shift from passenger cars.

Our estimation uses a simplified approach based on travel elasticity. The latter is defined as the rate at which passenger substitute one mode of transport for another, given a change in the relative characteristics of these modes. Travel elasticities and cross-price elasticities may be potentially useful from a policy or management viewpoint (e.g. public transit planning) as they can help predict the reaction of the market for transportation to changes in features of transport modes such as variation of relative prices or level of service, especially when historical data is not available for building theoretical models to predict how a newly implemented rail system would attract passengers from other modes.

Our approach reference is Todd Litman paper - "Transit Price Elasticities and Cross-Elasticities" – published in 2004 by Victoria Transport Policy Institute. In this paper, Litman summarized price elasticities and cross-elasticities for use in public transit planning, through examining previous research on urban and intercity transit elasticities in different countries such as France, UK, the U.S, Australia, etc. using multimodal models to "predict how various combinations of changes in transit fares, transit service, and vehicle operating costs would affect transit ridership and automobile travel". In his study, Litman took into consideration the major factors that affect transit elasticities (i.e. transit modes, user type, trip type, geography, type and direction of price change, etc.) in the short- and medium/long-runs in order to propose generic transit cross-elasticity values including those for transit ridership with respect to auto operating cost, and for automobile travel with respect to transit cost (Litman, 2004).

In our analysis, “price” refers to marginal costs perceived by users, which may include not only monetary costs, but also nonmarket costs such as in- and out-of-vehicle travel times, quality and frequency of service, fares and vehicle operating costs (VOC) and all other travel characteristics that directly affect modal choice, and thus determine the size of the modal shift.

We also consider automobile travel as a substitute for transit travel, in particular rail travel. In this context, users would choose to shift from passenger car to rail depending on the comparative advantage of the latter with respect to automobile travel. Therefore a decline in rail travel relative cost would reduce automobile travel demand. Similarly, any increase in relative cost of driving tends to increase rail travel demand.

Table 11 summarizes the generic elasticity values recommended by Litman. The short-term values are retained in our study, and are based on the compilation numerous studies that have calculated elasticity and cross-elasticity measures to predict how various combinations of changes in transit fares and service, as well as VOC would affect transit ridership and automobile travel (Litman, 2004).

Table 19: Generic Transit Elasticity Values Retained in the Study

Cross-Price Elasticity	Market Segment	Short Term	Long Term
Transit ridership with respect to auto operating costs	Overall	0.05 – 0.15	0.2 – 0.4
Automobile travel with respect to transit costs	Overall	0.03 – 0.1	0.15 – 0.3

Source: (Litman, 2004)

a. Under Transit-Oriented Policy

In our study, a transit-oriented policy is defined as a ridership-based policy that provides a framework for the cost- effective measures applied to improve transit service. Under this policy, authorities mainly seek to increase transit ridership by means of reducing relative transit costs. Transit-oriented policy includes various actions with different levels of impact on transit cost and ridership. Examples of transit-oriented policy measures are relatively low cost options (e.g. marketing and enhanced public awareness programs), fare policies, adequate financing, and other public policies supporting transit ridership growth and thus decreasing the usage of low-occupancy vehicles such as automobile through demand or market strategies (e.g. system/service expansion, system/service operational improvements) (EPA, 1992).

3 scenarios are considered under this policy as shown in Table 20 below.

Table 20: Transit-Oriented Policy Scenarios

Scenario	Assumption
Base-Case	The relative cost of rail transport decreases by 1.5%
High-Transit	The relative cost of rail transport decreases by 3%
Low-Transit	The relative cost of rail transport decreases by 0.5%

Source: Author's Assumptions

The mid-point value of 0.065 for short run analysis is used in our calculations for the cross-price elasticity of automobile travel with respect to rail travel cost. Due to variability and uncertainty, sensitivity analysis is conducted in our analysis of cross-price elasticity for elasticity values in the range of 0.03-0.1.

b. <u>Under Cost Internalization Policy</u>

In our study, a cost internalization policy is defined as a VOC-based policy that provides a framework for the cost- effective measures applied to reduce automobile travel. Under this policy, authorities mainly seek to reverse the trend of auto-dependency by means of internalizing the transport-related external costs (i.e. congestion costs, accident costs, air pollution and noise costs etc…) and adding the latter to automobile operating costs, thus increasing relative automobile travel costs. According to the welfare theory approach, internalizing non-market external costs using market-based instruments would reduce transport-related negative externalities, lead to a more efficient use of infrastructure and promote equity between transport users. Examples of cost internalization measures include introducing mark-ups or new taxes or charges based on external cost levels, or differentiating km-based charges or taxes, local road pricing schemes and carbon content-based fuel taxes. It is worth noting that two kinds of policy impact assessment are needed to analyze different internalization measures: (1) qualitative assessment based on literature and (2) quantitative assessment based on modeling (CE Delft / INFRAS / Fraunhofer / IWW / UG, 2008).

3 scenarios are considered under this policy as shown in Table 21 below.

Table 21: Cost Internalization Policy Scenarios

Scenario	Assumption
Base-Case	The VOC increases by 1.5%

High-VOC	The VOC increases by 3%
Low-VOC	The VOC increases by 0.5%

Source: Author's Assumptions

The mid-point values of 0.1 for short run analysis are retained in our study of the cross-price elasticity of rail ridership with respect to auto operating. Due to variability and uncertainty, sensitivity analysis is conducted in our analysis of cross-price elasticity for elasticity values in the range of 0.05-0.15.

The results of the sensitivity analyses are presented in details in Table 34 and

Table 35 in Appendix II.

2. *Estimation of Passenger Road-to-Rail Modal Shift External Benefits on Lebanese Roads: A Rule of Thumb*

a. Rule of Thumb and Assumptions

i. Rule of Thumb

The transport-related external costs on Lebanese roads in 2015 are measured using an estimate of country-level daily motorized trips. Thus a reduction in road traffic due to modal shift to rail results in an equal reduction of monetary external costs.

This rule of thumb is applied to all cost categories in our study, except congestion cost reduction. The latter is estimated using expected auto travel time savings from the modal shift.

ii. Assumptions

The following table presents the historical trip levels (in Daily Motorized Trips) used in our simulation within the study areas, and the expected traffic in these areas in year 2015 at estimated 3% average annual traffic growth (Egis International, 2012).

Table 22: Estimation of Daily Motorized Trip in Lebanon and the Particular Study Areas - GBA, Jounieh Area and Tripoli Area

Study Area	Daily Motorized Trips	
Lebanon	Year 2000	Year 2015 [f]
	2,800,000	4,362,309
GBA	Year 2005	Year 2015 [f]
	1,568,000	2,892,483
Jounieh Area	Year 2005	Year 2015 [f]

	183,000	269,743
Tripoli Area	**Year 1998**	**Year 2015** [f]
	500,000	826,424

Sources: (Dar/IAURIF, 2005), (IBI Group/TEAM International/SETS, 2008), (DMJM/Harris International/IBI Group, 2003)

In order to avoid double counting of motorized trips in our study, we assume that only 60% of total 2015 motorized trips in the GBA, Jounieh area and Tripoli area are made along the subject suburban corridor.

Table 23 and Table 24 show the average speed and share of total trips used in our study for urban peak and off-peak travel differentiation, and the value of travel time (VOT) retained in our estimation.

Table 23: average speed and share of total trips for urban peak and off-peak travels

Trip Type	Average Speed (km/h)	% of Total
Urban Peak	17.6	51%
Urban Off-Peak	39.1	31%

Source: (MoE/UNEP/gef, 2012)

Table 24: VOT for Private Passenger Cars in USD/hour

Year	VOT (USD/hr)
2011*	1.5
2015 [f]	1.75

Source: *(Egis International, 2012)

b. Results, Discussion and limitations

Table 25 and Table 26 show the results of theoretical road-to-rail modal shift in the study area based on the simplified elasticity analysis under the transit-oriented policy and the cost internalization policy, respectively. This modal shift percentage is expressed in terms of expected decrease in auto travel under the former policy, and in terms of increase in transit travel under the latter policy.

Table 25: Theoretical modal shift from auto to rail under transit-oriented policy

Scenario	Expected % Decrease in Auto Travel
Base-Case	10%
High-Transit	20%
Low-Transit	3%

Source: Author's Calculations

Table 26: Theoretical modal shift from auto to rail under cost internalization policy

Scenario	Expected % Increase in Transit Travel
Base-Case	15%
High-Transit	30%
Low-Transit	5%

Source: Author's Calculations

i. Reduction in Congestion Costs

Travel time is the primary determinant of road-to-rail modal shift. Thus, at the current dramatically high level of congestion on Lebanese roads, a significant share of motorized trips are expected to be captured by rail, given that the use of the latter would result in important TT savings on roads in the subject areas. These TT savings are calculated in minutes/day for an approximate Tripoli-Beirut distance of 82.2 km and transformed to 2015 values assuming 250 working days per year.

Table 27: Congestion Cost Reduction under Different Policies and Scenarios

Transit-Oriented Policy		Cost Internalization Policy	
Scenario	% Reduction	Scenario	% Reduction
Base-Case	56%	Base-Case	53%
High-Transit	60%	High-VOC	59%
Low-Transit	50%	Low-VOC	44%

Source: Author's Calculations

ii. Reduction in Other External Costs

Table 28 and

Table 29 show the results of external cost reduction in the long and short terms under (a) transit-oriented policy and (b) cost internalization policy.

Table 28: External cost reduction in the long and short terms under transit-oriented policy

Scenario	% Short-Term Reduction	% Long-Term Reduction
Base-Case	4%	13%
High-Transit	7%	25%
Low-Transit	1%	4%

Source: Author's Calculations

Table 29: External cost reduction in the long and short terms under cost internalization policy

Scenario	% Short-Term Reduction	% Long-Term Reduction

Base-Case	6%	17%
High-VOC	11%	34%
Low-VOC	2%	6%

Source: Author's Calculations

It is crucial to note that long-term price elasticities are higher than short-term price elasticities, as the former reflect a travel choice becoming more and more sensitive to price changes. Both short- and long- run elasticities are higher under the cost internalization policy, given that most potential transit riders are discretionary riders currently relying on automobile travel due to its price affordability. However, once external costs of road transport are internalized and thus included in the auto operating costs, the cost of travel may become relatively unaffordable which may trigger drivers to shift to passenger rail as the latter would offer a relatively lower all-inclusive cost of travel. Furthermore, a combination of both policies would be recommended in some specific modal choice behavior cases when riders are not responsive to changes in relative transit travel costs. For instance, a decrease of the latter accompanied with an increase of VOC would contribute to a more sizable potential road-to-rail modal shift.

iii. Result Summary and Limitations

A summary of the new estimated road-transport related external costs is presented in Table 30 below under different combined policy scenarios

Table 30: Summary of Transport-Related External Costs on Lebanese Roads in 2015 Should Tripoli-Beirut Railway Have Been Implemented

Cost Category	Transit-Oriented Policy		Cost Internalization Policy		% of Total Costs	% of GDP
	Scenario	Value 2015[f] (in 000' USD)	Scenario	Value 2015[f] (in 000' USD)		
Accidents	Base-Case	739,980	Base-Case	724,940	29%-31%	1.6%
	High-Transit	712,048	High-VOC	681,969		
	Low-Transit	758,600	Low-VOC	753,587		
Air Pollution	Base-Case	481,255	Base-Case	471,474	19%-20%	1%
	High-Transit	463,090	High-VOC	443,527		
	Low-Transit	493,365	Low-VOC	490,105		
Climate Change	Base-Case	111,654	Base-Case	109,385	4%-5%	0.2%
	High-Transit	107,440	High-VOC	102,901		
	Low-Transit	114,464	Low-VOC	113,707		
Environmental Noise	Base-Case	429,432	Base-Case	420,704	17%-18%	0.9%
	High-Transit	413,223	High-VOC	395,767		
	Low-Transit	440,238	Low-VOC	437,329		
Congestion	Base-Case	652,938	Base-Case	701,837	26%-32%	1.5%
	High-	592,396	High-	608,696		

	Transit		VOC			
	Low-Transit	743,750	Low-VOC	841,548		
TOTAL	**Base-Case**	**2,415,259**	**Base-Case**	**2,428,340**	**100%**	**5.2%**
	High-Transit	**2,288,197**	**High-VOC**	**2,232,860**		
	Low-Transit	**2,550,417**	**Low-VOC**	**2,636,276**		

Source: Author's Calculations

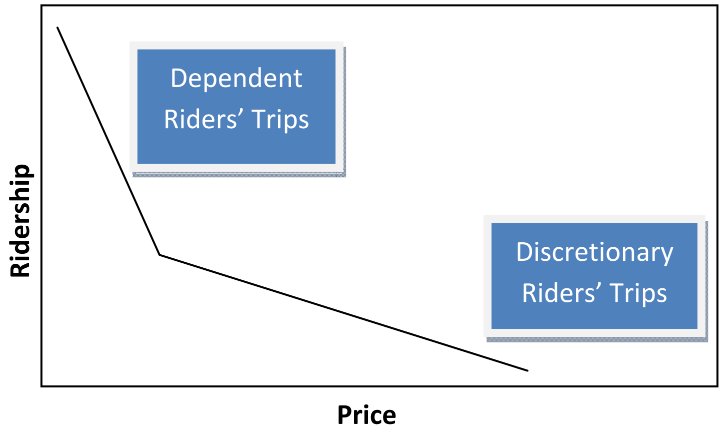
With the potential revival of the Railway, the total external costs are theoretically estimated to decrease by 21 to 30 % under both transit-oriented and cost internalization policy scenarios, thus lowering the negative welfare effect of externalities on economic growth. It is worth noting that the size of external cost reduction is subject to increase over the long term period when riders become more responsive to changes in price.

From this perspective, the Railway revival can be regarded as a way to address the paradox of sustainable development in Lebanon. This requires the efficient use of available resources as well as a proper maintenance of the assets. This would make rail transport cost-effective and continuously responsive to rapid changes in travel demand. Once it benefits from self-financing, the rail sector would ultimately become a major contributor to the sustainable growth/development of the national economy (CDR, 2006).

In order to account for uncertainty, a sensitivity analysis is conducted for the short-term elasticities, using the elasticity value range of 0.03-0.1 for cross-price elasticity of automobile travel with respect to rail travel cost(Litman, 2004) under different scenarios of transit-oriented policy, and the elasticity value range of 0.05-0.15 for cross-price elasticity of rail ridership with respect to auto operating cost(Litman, 2004) under different scenarios of cost internalization policy. and in Appendix I show the results of the sensitivity analysis for short-term elasticity values under transit-oriented policy and the cost internalization policy respectively.

Similarly to the previous exercise of external road transport-related costs, the major general limitation resides in the fact that the key pieces of data and analysis are still not available. For instance, due to lack of data availability, our analysis does not include any differentiation of motorized trips by travel purpose. However, it is worth noting that, depending on the trip motive, some travelers are more or less sensitive to changes in travel cost and thus price and cross-price elasticities are not the same for all trip types. For instance, leisure travelers may be much less responsive to fares and access/egress costs than commuters. Similarly, the price elasticities for off-peak trips are typically 1.5 to 2 times higher than peak-period elasticities, as peak-hour travel essentially consists of commute trips. Furthermore, travel elasticities are also affected by other factors such as user type or market segment and service geography. For example, transit-dependent riders are usually less price responsive than discretionary riders. In addition, many demographic groups such as low-income groups, non-drivers, people with disabilities, students and the elderly tend to be more transit-dependent. In most communities, these categories generally constitute a relatively small portion of population but a larger percentage of transit users. As for the geography, it has been noted that per capita annual transit ridership is positively correlated with city size. In other words, the larger the city, the lower price elasticities tend to be. This is due to the fact that large cities have a greater share of transit-dependent users than small cities and suburbs, and due to increased parking and congestion costs as well as improved transit service given the existence of economies of scale in large metropolitan areas (Litman, 2004). Figure 5 illustrates the kink in travel demand curve due to the price sensitivity difference between transit-dependent and discretionary passengers.

Figure 5: Kinked Transit Travel Demand Curve



Source: (Litman, 2004)

Thus a relatively large cost reduction is needed to attract motorists to rail, since they are discretionary riders. Furthermore, they may be more responsive to the quality of service (i.e. speed, frequency, and comfort), and higher VOC of automobile (i.e. vehicle user fees such as road or parking pricing). For this reason, increasing transit ridership requires a mix of pricing and incentive strategies to attract auto travelers out of their cars. For instance, combinations of fare reductions and discounted passes, higher VOC, improved rail service marketing can be particularly effective at decreasing automobile use and increasing rail ridership (Litman, 2004).From this perspective, it is vital to note that no single transit elasticity value applies in all situations, given that, in addition to riders' type, various factors affect price sensitivities including type of trip (e.g. leisure vs. commute), geographic conditions, and time period. Therefore additional review and research is needed to improve and validate these values, apply the needed modifications in particular circumstances.

Like most rules-of-thumb, the approach used to estimate the theoretical potential reduction in road-related external costs may be useful for rough analysis, but is too simplistic for detailed planning or modeling, being sensitive to specific demographic and geographic conditions and requiring calibration for each study area. Needless to say, the realism of the mode shift size in the different policy scenarios and for the different elasticity values study strongly depends on the nature of the system (i.e. light rail, high-speed rail…)and the maximum ridership capacity of the network.

In our study we only account for the theoretical potential reduction in transport-related external costs should the railway line be put in service. However, it is worth noting that the implementation of rail service would either increase or limit the size of these reductions depending on the nature of the potential system. For instance, assuming that the Tripoli-Beirut rail will run at 45 km/hr (standard gauge average speed), riders would benefit from additional travel time savings estimated in the range of 35-310 Million USD for 2015, depending on the different scenarios and policies considered in our study. As a counterexample, accounting for the annoyance (set at 5 dB above the levels for road noise) and health damage (assumed to be the same for road and rail traffic starting from 70 dB(A)) generated by rail noise (CE Delft/INFRAS/Fraunhofer ISI, 2011) would limit the overall theoretical reduction in environmental noise costs should the rail line be implemented. Similarly, the extent to which we will benefit from emission reductions due to railway revival depends on how environmentally viable the system will be.

Besides the positive externalities that could be generated by the revival of Tripoli-Beirut railway, it would be of interest to conduct thorough research on other nationwide benefits such as those related to potential reduction in the unemployment rate due to job creation in the rail sector, in the government budget deficit due to revenues from transit fares, as well as those related to real estate development around the stations. Regarding the latter benefit, it is crucial to note that well-designed transit oriented development in general can help improve the quality of life and accessibility of the region, and contribute to a sustainable economic development. This could be applicable to the Tripoli-Beirut Railway case if the potential facility design takes into account the anticipation of an efficient urban development. Joining efforts between concerned public authorities including RPTA and between private stakeholders including potential operators and property owners along the ROW is crucial to prepare an effective urban development plan and insure cost-effective management of the system(DMJM/Harris International/IBI Group, 2003).

C. Multi-Dimensional Challenges and Barriers for the Railway Revival

1. Key Constraints for Modal Shift from Road to Rail

Among the factors that may hinder the potential railway system from being efficient and thus attracting ridership are (1) decentralization of activities which renders serving urban areas more difficult and expensive; (2) fixity of the rail system which may render its capacity to follow the dynamic rapid growth in travel growth controversial; (3) connectivity issues as the failure of rails to connect passengers with other modes; and (4) the fierce competition that may be faced by the rail sector with the existence of affordable alternative road transport modes (Rodrigue, Comtois, & Stack, Chapter 7 - Urban Transportation, 2006). In Lebanon, as most travelers along the Northern suburban corridor are discretionary riders, and due to the continuously increasing trend of auto-dependency, the size of the road-to-rail modal shift depends on the extent of increase in the relative auto travel cost through cost internalization policy. Thus a transit-oriented policy under which efforts are made to improve the service including the reduction of relative rail travel cost may not be enough to stimulate a positive response from drivers to shift to rail and reverse the automobile trend.

Besides, no matter how sophisticated and accurate the estimation method for the potential ridership on the new service may be, it is difficult for the simulation model to include all possible factors to which ridership may be sensitive (e.g. frequency, comfort and convenience of the service, ability to achieve suitable penetration of the downtown, price and availability of parking, availability of new toll road facilities, taxation policies on automobiles and fuel). Furthermore, the fact that there is no recent history on high-quality public transit in the country may render the ridership / potential modal shift prediction exercise more complicated and uncertain (DMJM/Harris International/IBI Group, 2003).

2. Physical/Technical Barriers

The development of the entire rail ROW to appropriate geometry is indispensable for implementing a comprehensive rail system. In other words, the entire rail system wouldn't be functional until the entire ROW is fully available. However, regaining complete and exclusive use of the ROW by RPTA is subject to time constraints and involves conflict of interests between stakeholders such as private property owners along the ROW. The main reason behind such constraints is that although parts of the ROW are still intact, there are inconsistent land uses including building encroachments on access ways to bypass routes. (DMJM/Harris International/IBI Group, 2003).

Furthermore, new grade separations at intersections with main roads, new river crossings, and tunneled access into main stations are needed for the ROW to be compatible with the eventual rail service (CDR, 2006).

Another physical constraint is related to the purchase of rail equipment. This could be done either through full procurement or small-fleet acquirement in the short-term before full expansion over a longer period of time. In this regards, decision makers would be faced with many financial or supply shortage obstacles depending on the purchase option chosen (DMJM/Harris International/IBI Group, 2003).

More details related to physical barriers are presented in Table 33 of Appendix I.

3. Institutional Barriers

RPTA has been designated as the lead agency for the coastal railway, under the policy guidance of the Ministry of Public Work and Transport (MoPWT).

Although this entity owns a major part of the ROW, it needs to be authoritatively/institutionally capable of reclaiming the used parts so that the rail system can be fully implemented. In addition, this entity needs to lead daily operating tasks and focus on the procurement plan options (CDR, 2006), to authorize more detailed engineering/design work for complete ROW acquisition, and to immediately prohibit any further incursions into the ROW or station areas (DMJM/Harris International/IBI Group, 2003).

It is worth noting that the political risk is also involved in both the inability of solving the traffic problems after investment in the railroad project, and the inherent complexity of recovering the ROW from its current uses (through the removal of obstructions on the ROW) or creation of new ROW circumventing such uses In addition, providing high-quality public transit requires long term, stable implementation mechanisms for (i.e. multi-year planning, capital investment, employee training, and marketing. In Lebanon, annual legislative appropriation mechanisms are accompanied by political interference with management decisions. Therefore increasing the independence and reliable funding streams for public agencies, and/or long term contracts with private companies is needed. In fact, the identification, commissioning and management of contracted concessionaires to serve as industry partners involve a complicated process, especially if taken in charge by the public sector. In this case, the project success would be threatened by political intervention as political circumstances change in a parliamentary system. However, should the private sector be an integral part of this process, the eventual railroad project would have more chance of success as private companies would be more able to create and sustain multi-year stability for a long-range undertaking, In this context, the ability of the RPTA to coordinate with the private sector for the implementation, operation and maintenance of the rail system would enhance financing and funding opportunities (DMJM/Harris International/IBI Group, 2003).

Thus in order to overcome all technical and other challenges, this public entity needs to be empowered enough to be put in charge for leading the planning, execution and post-execution phases of the potential rail project. In this regards, it is crucial that such an entity be granted full authority and decision making within the project scope.

CHAPTER IV

CONCLUSION

Our research has proposed a less traditional view of the transport sector as a way to study the nature of economic growth/development. In particular, railway transportation can be viewed as a way to address the sustainable development paradox. These views have been applied to the transport sector in Lebanon, a small open developing country with a unique mix of socio-economic, geopolitical and other particular features, through the study the case of the potential revival of the Tripoli-Beirut railway as a way to lower the negative welfare effects of the unsustainable road transport sector on economic growth and development in the country. In this context, we have justified the need to promote a holistic view of economic growth and development using transport sector analysis in Lebanon, and particularly the measurement of passenger road transport externalities as one measure of the sustainability of economic growth in the country.

In Chapter I, we tackled the controversial policy question of whether transport and sustainable economic growth/development are coupled or decoupled through examining the complex multi-fold relationship between urban transport, economic growth, economic development and sustainability. In Chapter II, the economic importance of transportation was approached using a public economics perspective to measure the external costs unsustainable transport systems generate the resulting welfare loss. In this context, our estimation of passenger road-related external costs in Lebanon for 2015 shows that the negative externalities the current road transport sector incurs amount to 3.3 Billion USD or 7.2% of the GDP.

In Chapter III, we examined the possibility of the potential revival of the Tripoli-Beirut Railway as a way to lower the welfare effects of these externalities on economic growth using this mode that is globally considered among the most sustainable means of transport. Assuming different sizes of potential road-to-rail mode shift based on a simplified elasticity approach and under two different policy scenarios: (1) transit-oriented policy scenario and (2) cost internalization policy scenario, we have concluded that the overall reduction of road transport-related external costs would range from 44 to 62% for congestion costs and from 1 to 17% for other cost categories.

What we aspire to based on these results is to urge decision makers, from engineers and developers to economists and policy makers, to change the way they interpret the progress and regress of nations(Dasgupta, 2013). If their way of thinking becomes governed by a culture of multi-disciplinary analysis, they would realize that for their models to be applied to the real world, it is impossible to build them in unrealistic frameworks which exclude social, spatial or environmental elements lying behind the causes and/or effects of the problem(s) addressed.

At the end, it is crucial to note that, as the validity of our analysis may be limited by the availability of data, we hope that in future research some of these aspects tackled provide insight to cost internalization and growth–oriented transport policies.

Smart Mobility-Growth and Growth-Oriented Transportation Policies: The Desirable Paradigm Shift

The fundamental conclusion of our research is that transport and economic growth development are inextricable twins under the sustainability hypotheses. From this perspective, if transport systems are relatively unsustainable, any initial positive effect of transportation on economic growth could be reversed, generating a set of environmental, social and economic problems, which may put the country in a situation that could be even worse than the starting point. Once the external costs of transport are internalized, and a considerable shift towards more sustainable transportation systems is made, the negative economic, social and environmental effects of transport could be offset and even reversed, fostering sustainable economic growth/development. Thus, the culture of unconditional economic growth, not only is harmful in the longer-term to the environment and society, but also would have negative repercussions on the extant economic growth itself, even prior to the interference of the future generations.

Society, the environment and the economy are intertwined pillars of welfare. Thus the absence of any of them would move a country into the vicious circle of unsustainability and self-destructive economic growth. The transport sector is a core component of the economy, and may have huge double-sided effects on growth, development and welfare. In other words, while efficient/sustainable transport systems can serve the vital function of providing socioeconomic opportunities, transport systems lacking efficiency/sustainability generate economic costs and welfare losses, and thus hinder economic growth.

In fact, the future growth rate of the global economy is estimated at more than 50%, with a rapid urban sprawl, and technological revolutions. To keep up with this pace and respond to the rapidly changing demand patterns, global infrastructure, urban, land use and energy system investments are expected to reach 90 trillion USD (The Global Commission on the Economy and Climate, 2014). The extent to which these changes would exacerbate welfare losses highly depends on the way the resources will be managed. In this context, the vital question is whether future patterns of growth, productivity and living standards will be shaped by unsustainable practices promoting quantitative self-destructive growth. The answer to this question depends on the following factors: (1) global awareness to the threatening externalities invading today's economies and mainly emanating from urban areas viewed as the central dynamic engines of the economy; and (2) the extent to which economies are benefiting from the structural and technological change now occurring in the global economy, as a way to promote lasting economic growth while at the same time tackling the immense sustainability challenges. Transport lies at the core of this dangerous controversy, for it plays a vital role in shaping cities with different growth and development patterns. For instance, efficient urban development models11 prioritize high-quality public transit systems and minimize auto dependency and road traffic congestion and smarter mobility systems. By shifting towards such alternatives for the unplanned unsustainable urban models, substantial economic and social benefits (e.g. air quality improvement, significant cost savings in the transport sector …) would be unlocked over medium and longer periods of time. Positive agglomeration effects of greater density would also be produced such as infrastructure-related productivity gains and economies of scale. However, this necessitates a global call for promoting the economics of change. It's about changing the perception that a trade-off exists in the short run between economic growth and sustainability. Such transformational change offers an opportunity to drive economic growth not only in terms of incomes and GDP, but also in terms of welfare benefits. Therefore one needs to understands that the quality of growth matters as much as its rate. To serve this purpose, developing and making use of a wider set of economic indicators is highly recommended. For instance, high growth rates generating huge negative economic/social/environmental externalities would

[11] "Development models based on well-managed lasting growth promoting higher densities, mixed-use neighborhoods, walkable local environments, and – in Global Megacities and Mature Cities – the revitalization and redevelopment of urban centers and brownfield sites, complemented by green spaces." (The Global Commission on the Economy and Climate, 2014)

question the sustainable performance of the economy. On the contrary, any economy with high sustainability indicators but slower GDP growth can be viewed as well-performing economy (The Global Commission on the Economy and Climate, 2014).

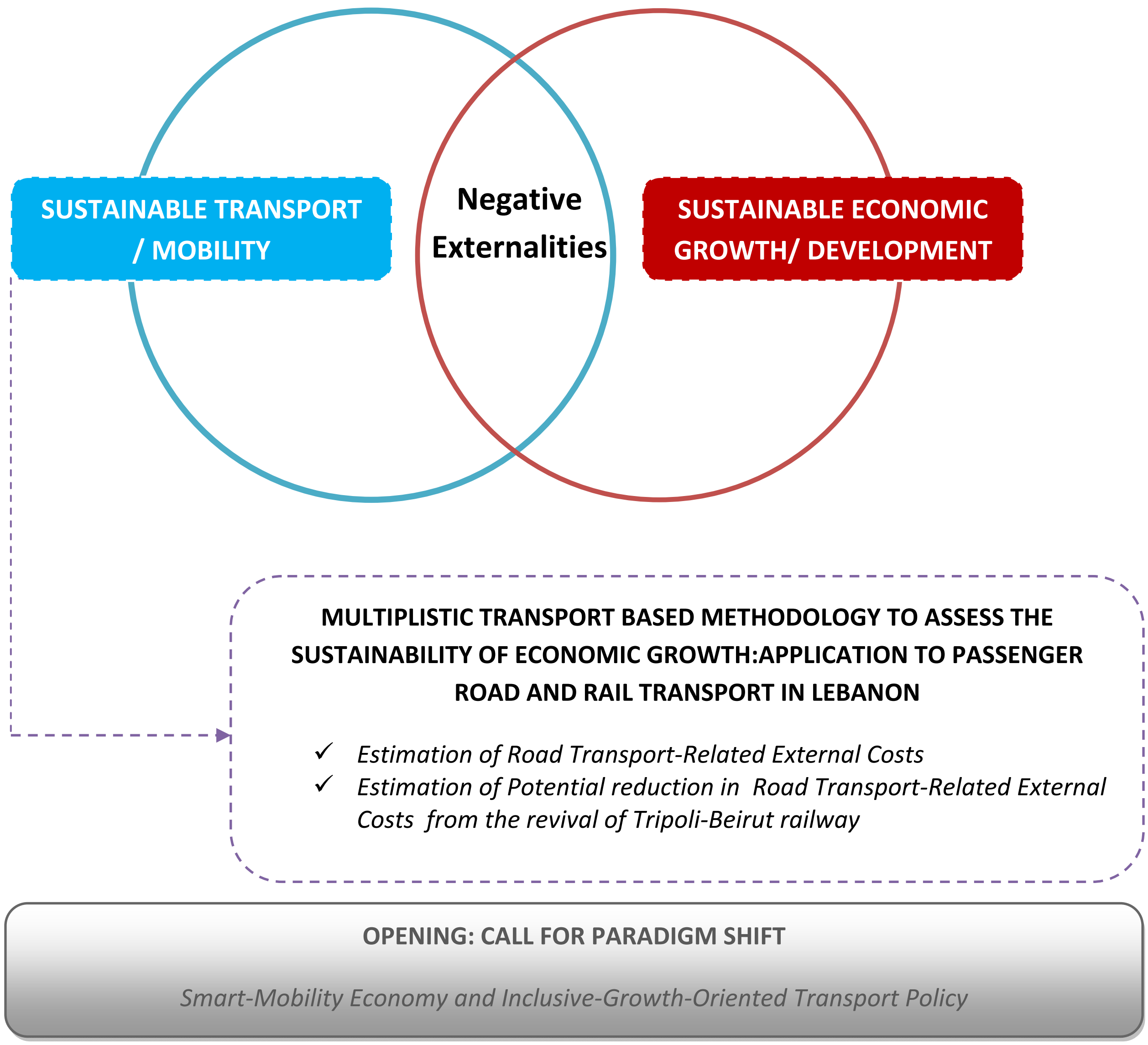
This reinforces the concept of “better growth” pioneered by the Global Commission on the Economy and Climate and defined as follows:

“…growth that is inclusive (in the sense of distributing its rewards widely, particularly to the poorest); builds resilience; strengthens local communities and increases their economic freedom; improves the quality of life in a variety of ways, from local air quality to commuting times; and sustains the natural environment. All these benefits matter to people, but they are largely invisible in GDP, the most widely used measure of economic output.”

(The Global Commission on the Economy and Climate, 2014)

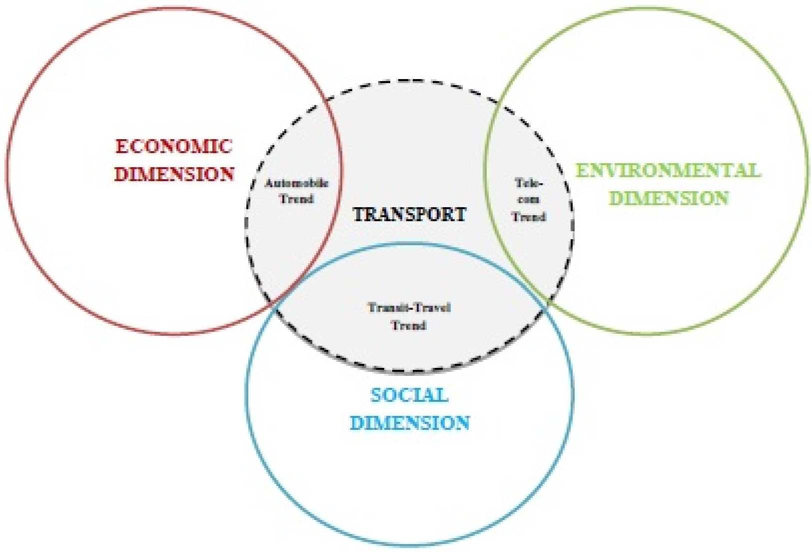
APPENDIX I – STUDY FRAMEWORK AND TECHNICAL SOURCES

Figure 6: Study Framework



Source: Author's Analysis

Figure 7: Interaction between transportation and sustainability spheres

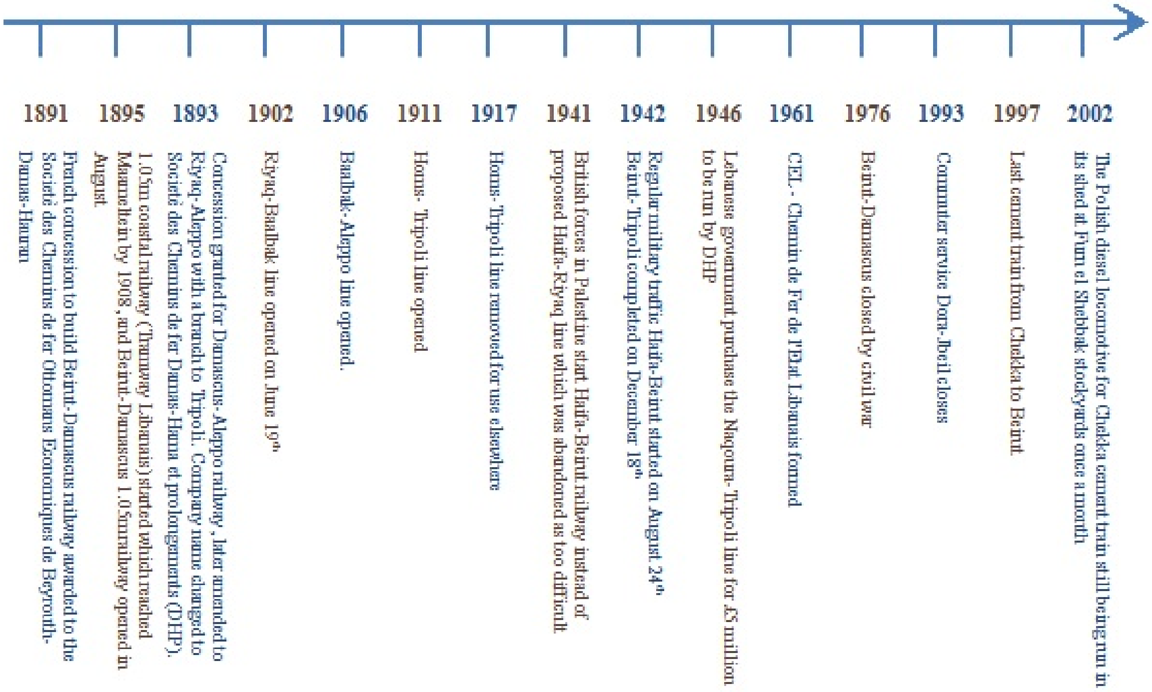


Source: Author's Analysis

Table 31: Macroeconomic Development Indicators used in the study

Macroeconomic Indicator	Value 2015 (%)	Data Source
GDP Growth	2.5	World Bank Group (WBG)
Population Growth	0.96	World Bank Group (WBG)
GDP/Capita Growth	1.5	World Bank Group (WBG)
Inflation Rate – GDP Deflator	4.4	International Monetary Fund (IMF)

Figure 8: The history of Railways in Lebanon



Source: (Al Mashriq, 2009)

Table 32: Railway Passenger Traffic (1961-1970)

Year	Number of Passengers	Number of passenger-km	Annual Ridership Growth
1961	71,000	5.5	
1962	73,000	6.0	9%
1963	64,000	5.3	-12%
1964	73,000	5.8	9%
1965	80,000	6.7	16%
1966	80,000	6.6	-1%
1967	80,000	6.0	-9%
1968	88,000	6.7	12%
1969	78,000	7.3	9%
1970	76,000	7.4	1%

Source: (IBRD, 1973)

Table 33: Rail Sector in Lebanon

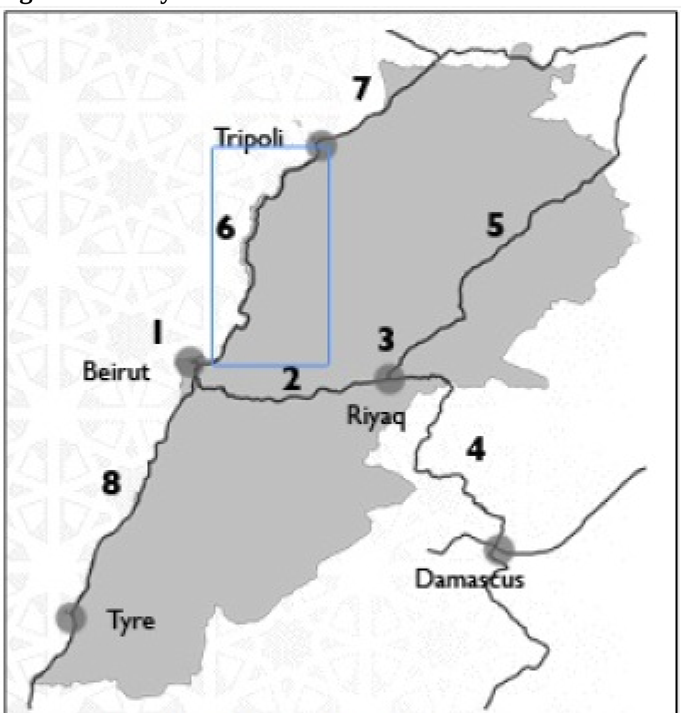
Component	Present Situation	Target Situation	Projects	Impact	Technical Constraints
Physical Stock	Many parts of the ROW encroached upon	No encroachments along the ROW	Clearing the rail ROW of encroachments	Provides opportunities to use the ROW in a beneficial manner.	Encroachments can be very hard to remove involving political and social aspects.
	Service non-existent	The rail ROW is used as public transport corridor (for buses in the first stage then for light rail if proven feasible). the suggested sections for these corridors, in addition to the BRT between Beirut and Jounieh (mentioned under "Roads"), are: Beirut-Saida; Beirut-Sofar, and Jounieh-Tripoli	Turning rail ROW sections into public transport corridors, including provision of facilities such as terminals and stations. These sections are: Beirut-Saida, Beirut-Sofar, and Jounieh-Tripoli (Feasibility Study)	Increased chances of mass transport, bus or rail, to compete against private cars.	This project depends on the outcome of the ongoing study on the revitalization of the public transport industry. Also, rail may be viable only when linked to the regional network, depending on the schemes on this network.
			Turning rail ROW into public transport corridor, for the following sections: Beirut-Saida, Beirut-Sofar&Jounieh-Tripoli (Design/Construction)		

	Network largely defunct	Viability of link to the north of Tripoli established and link operational	Rehabilitate Tripoli-Syrian Border link (Construction - Infrastructure only)	Enhances Tripoli Port accessibility to regional transport networks.	Depends on regional schemes.
	Three routes were operating in the past, for which a reserved ROW exists: o Naqoura-Beirut-Tripoli o Beirut-Damascus o Riyaq-Homs	Viability of rail operations for passengers and goods within Lebanon determined.	Feasibility study for rail operations in Lebanon (Study).	Establishment of the best way to use the existing rail ROW and benefits obtained from such use.	Short distances, such as the case of trips inside Lebanon, do not warrant heavy rail operations. Study has to incorporate regional rail operations. Also, light rail in urban areas is constrained by the narrow streets in those areas.
Institutional Setup	Responsibility of MPWT through DGLMT and OCFTC. The latter is in charge of managing and operating the rail network	Proposed General Authority for Land Transport (LTA) should be established and operational, in a manner that separates regulatory and operational responsibilities.	Establish LTA with proper staffing and equipment *Already considered under Passenger Transport in Roads Sub-Sector*	Better control of the regulations in the sub-sector.	Establishing laws should be carefully studied

		Operating rail company	Establish rail operating company	Better control of the operations in the sub-sector.	Depends on viability of rail operations.

Source: (CDR, 2006)

Figure 9: Study Area



1. Beirut Station and Stockyards
2. Beirut - Riyaq*
3. Riyaq Station and Stockyards
4. Riyaq - Damascus*
5. Riyaq – Homs
6. Beirut – Tripoli
7. Tripoli – Abboudiyeh
8. Beirut – Naqoura

* 1.05m narrow gauge ABT track lines. The rest are standard gauge.

Source: (Al Mashriq, 2009)

APPENDIX II – SENSITIVITY ANALYSIS FOR SHORT-TERM CROSS-PRICE TRANSIT ELASTICITY VALUES

Table 34: Result of the sensitivity analysis for short-term elasticity values under transit-oriented policy

Short-Term Elasticity Values - Estimation Range	0.03	0.04	0.05	0.06	0.065	0.07	0.08	0.09	0.1
Response to decrease in relative transit costs: % reduction in passenger total motorized trips estimated along the study area									
Scenario 1 (Base-Case)	5%	6%	8%	9%	10%	11%	12%	14%	15%
Scenario 2 (High-Transit)	9%	12%	15%	18%	20%	21%	24%	27%	30%
Scenario 3 (Low-Transit)	2%	2%	3%	3%	3%	4%	4%	5%	5%

Source: Author's Calculations

Table 35: Result of the sensitivity analysis for short-term elasticity values under cost internalization policy

Short-Term Elasticity Values - Estimation Range	0.05	0.06	0.07	0.08	0.09	0.1	0.11	0.12	0.13	0.14	0.15
Response to increase in relative auto operating costs: % increase in passenger rail ridership along the study area											
Scenario 1 (Base-Case)	8%	9%	11%	12%	14%	15%	17%	18%	20%	21%	23%
Scenario 2 (High-VOC)	15%	18%	21%	24%	27%	30%	33%	36%	39%	42%	45%
Scenario 3 (Low-VOC)	3%	3%	4%	4%	5%	5%	6%	6%	7%	7%	8%

Source: Author's Calculations

Following these results, we can deduce the potential theoretical reduction in road transport-related external costs for different elasticity values and under different policy scenarios.

For instance, as previously examined, if we consider the mid-point elasticity values (i.e. 0.065 under the transit-oriented policy and 0.1 under the cost internalization policy), under the transit-oriented policy the % reduction in passenger total motorized trips estimated along the study area (due to decrease in relative transit cost) would range from 3% (low-transit scenario) to 20% (high-transit scenario). In this case the external costs from road traffic congestion and from other cost categories would be reduced by 50 to 60% and by 1 to 7% respectively. Similarly, under the cost internalization, the % reduction in passenger total motorized trips estimated along the study area (due to decrease in relative transit cost) would range from 5% (low-VOC scenario) to 30% (high-VOC scenario). In this case the external costs from road traffic congestion and from other cost categories would be reduced by 44 to 59% and by 2 to 11% respectively.

If we consider the lowest elasticity values (i.e. 0.03 under the transit-oriented policy and 0.05 under the cost internalization policy), under the transit-oriented policy the % reduction in passenger total motorized trips estimated along the study area (due to decrease in relative transit cost) would range from 2% (low-transit scenario) to 9% (high-transit scenario). In this case the external costs from road traffic congestion and from other cost categories would be reduced by 57 to 61% and by 1 to 3% respectively. Similarly, under the cost internalization, the % reduction in passenger total motorized trips estimated along the study area (due to decrease in relative transit cost) would range from 3% (low-VOC scenario) to 15% (high-VOC scenario). In this case the external costs from road traffic congestion and from other cost categories would be reduced by 53 to 61% and by 1 to 6% respectively.

However, if we consider the highest elasticity values (i.e. 0.1 under the transit-oriented policy and 0.15 under the cost internalization policy), under the transit-oriented policy the % reduction in passenger total motorized trips estimated along the study area (due to decrease in relative transit cost) would range from 5% (low-transit scenario) to 30% (high-transit scenario). In this case the external costs from road traffic congestion and from other cost categories would be reduced by 44 to 59% and by 3 to 17% respectively. Similarly, under the cost internalization, the % reduction in passenger total motorized trips estimated along the study area (due to decrease in relative transit cost) would range from 8% (low-VOC scenario) to 45% (high-VOC scenario). In this case the external costs from road traffic congestion and from other cost categories would be reduced by 34 to 58% and by 2 to 11% respectively.

Thus the overall reduction of road transport-related external costs would range from 44 to 62% for congestion costs and from 1 to 17% for other cost categories, depending on the different policy and elasticity scenario mixes.

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