# 國立交通大學

運輸與物流管理學系

碩 士 論 文

# 大眾運輸補貼計畫之評估：以巴拿馬為例

# Evaluation of Transit Subsidy Plans Using Analytic Hierarchy Process: A Case of Panama

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中華民國一０三年六月

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碩 士 論 文

A Thesis
Submitted to Department of Transportation and Logistics Management
College of Management
National Chiao Tung University
in partial Fulfillment of the Requirements
for the Degree of
Master
In
Transportation and Logistics

June 2014

Taipei, Taiwan, Republic of China
中華民國一０三年六月

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## 摘要

公共運輸補貼經費通常佔政府支出預算中相當龐大的比例，尤其許多經費係來自政府稅收，其是否有效運用，更令人關切。因此，如何有效運用補貼經費，以達到最大效益，實為一重要課題。基此，本研究旨在研提用以評選補貼分配方案的評估架構，並以全國人口集中的巴拿馬都會區為例，進行分析。該都會區正在規劃建置一條捷運線，若沒有適當的公車及捷運補貼，恐怕無法降低捷運及公車票價，進而吸引民眾使用，導致捷運投資之浪費。基此，主管當局也正思考在研擬一個補貼計畫，以促進大眾運輸系統之整合與發展。

本研究利用層級分析法（AHP）進行補貼計畫之評選。本評估架構包括補貼成本效益、補貼公平性、服務效果、服務品質、環境永續性、政府財務永續性、業者財務永續性等七大標的，並包括一至二個的準則。至於權重之決定係透過訪談巴拿馬運輸及經濟相關專家學者，並經計算而得。結果顯示。政府財務永續性權重最高。至於補貼計畫則以方案三為最佳，其次為方案二，而方案一最差。而方案三是提供營運補貼，並提供學生單一費率的優待票，並提供捷運與公車間之轉乘優惠。

**關鍵詞：大眾運輸補貼、層級分析法、補貼計畫。**

# Evaluation of Transit Subsidy Plans Using Analytic Hierarchy Process: A Case of Panama

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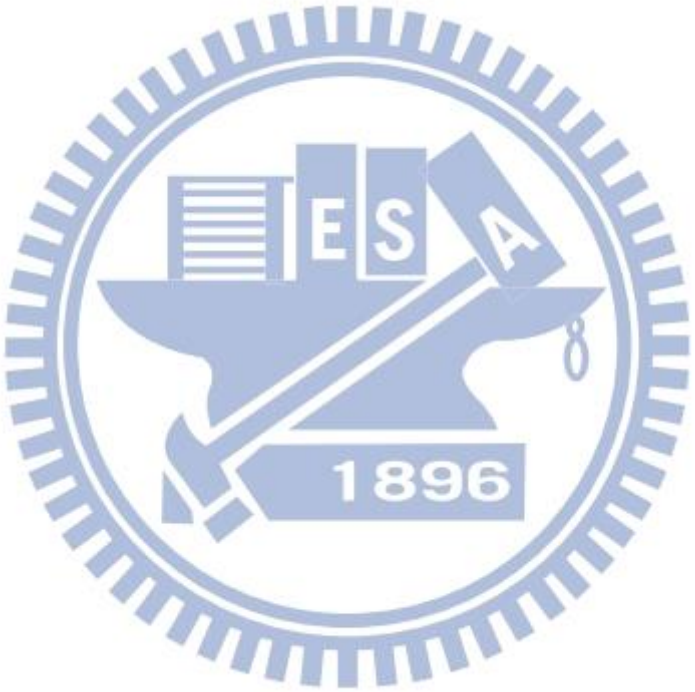
## Abstract

Transit subsidy is a common policy, used by many governments to support any increase of transport cost and therefore provide some direct benefit to users. In transportation, subsidies, are granted for many reasons and take an important part of government expenditure. This study is conducted to evaluate three different subsidy plans, to implement in the metropolitan area of Panama; where all the economic activity of this country is concentrated. The subsidy plans proposed by the authorities are aimed to provide financial assistance to the operators, develop new technologies and integrate the new systems (Metro and public bus); to benefit both the operators and users of public transportation systems.

The subsidy schemes proposed for Panama were evaluated using the Analytic Hierarchy Process (AHP). This method consists of a hierarchical representation, in which the decision problem is decomposed into different levels according to their common characteristics. Each level is evaluated by experts in transportation and economy of Panama. The experts were required to conduct a pair-wise comparison of the elements and provide the weights to determine the ranking of each alternative. The scheme 1, composed by a fuel tax rebate, a flat fare scheme, an operating subsidy for metro operations and a fare subsidy; was placed as the worst option. The second best option was, scheme 2, formed by a concessionary fare subsidy, capital subsidy for both systems (to invest in fleet and new technologies) and operating subsidy for metro operations. The best alternative according to the opinion of the experts was scheme

3, which offered a conditional operating subsidy, a flat fare subsidy, an operating subsidy for metro operations and a discount for transfers in both systems.

**Key Words**: Transit Subsidies, Analytic Hierarchy Process, Subsidy Schemes.

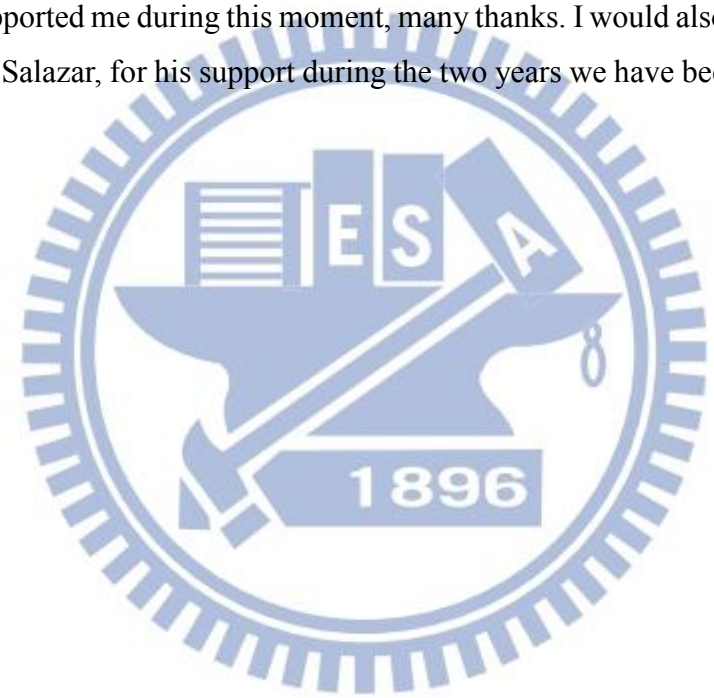


# Acknowledgment

Foremost, I would like to extend my sincere gratitude to my advisor Dr. Yu-Chiun Chiou, for his guidance and support during the development of this study. His advices guided me during all the study and allowed me to write and finish my thesis.

I would also like to thanks my professors and classmates, from National Chiao Tung University, for their support and remarks along this journey.

To my friends and family, who from the other side of the world helped me to accomplish my dreams and supported me during this moment, many thanks. I would also like to thanks a special person, Abdiel Salazar, for his support during the two years we have been apart, your love gave me strength.



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# 1. Introduction

## 1.1 Background and Motivations

A subsidy can be defined as a result of government action that confers and advantage on consumers or producers in order to supplement their income or lower their cost (Tscharaktschiew and Hirte, 2012). Subsidies in transportation are granted for many reasons and take an important part of government expenditure, due to the fact that in some cases are financed by state tax. Distribution, social equity, allocation of resources and transport externalities are some of the reasons that justify this economic help; but these are also some of the problems subsidy faces. The implementation of transit subsidies required proper evaluation for the efficient and effective performance of this policy. In many countries this policy is implemented to integrate the different transportation advances and improve their operations, others to provide low cost service for low-income households. Regardless of the purpose, it is important that suitable subsidy schemes that benefit both the operators and users of public transportation are proposed.

Transit subsidies in Panama were given for the first time in 1968, its main purpose was to eliminate the existent monopoly that the transportation industry faced at that moment. In this case the authorities were trying to focus on the welfare of low-income citizens, by lowering operating cost, fuel cost and the implementation of renewed vehicle fleet. The strategy was successfully implemented, unfortunately it failed into accomplish the proposed objectives. Misuse of state assets and mismanagement lead to the future collapse of the urban public transportation system of Panama. In 1993, the government approve more incentives for the bus operators, tax exemption in bus and parts cost. However, the service provided do not justify the benefits granted. To understand the real factor that determined the policy failure, first we must see inside the system, which was operated by independent operators who saw transportation as a business and were not concerned about the quality of service provided. Safety, service quality and proper regulation were some of the problems of public transport service. In 2011, a new system was introduced to solve the problems of the public transit service quality. The **Metrobus** was the key to upgraded and provide a more convenient service.

The implementation of this new transport system, caused the revision of the current subsidy established by the authorities. One of the main objectives of this system was to continue providing a low cost service. However the cost of this new and modern system was higher than the previous service. To regulate this situation, authorities proposed the implementation of a subsidy based on passenger per trips and an operating subsidy to cover fuel taxes. With only three years of its implementation (2011), the plan has received many complaints from the operators; who are presenting financial difficulties and are operating at lost. The principal objective, which was the improvement of service quality has not been achieved; instead, to reduce operating cost, bus operators have resorted to overcrowding, low frequency and decrease of passenger comfort, providing poor service. This prove that the current subsidy plans, are not achieving the objectives. With the need to provide new subsidies for the metro line, authorities are concerned about the efficiency and effectiveness of this policies. Future schemes proposed, must contemplate social distribution, integration among the systems and the proper allocation of the state budget, in order to obtain the best results of the subsidy schemes.

## 1.2 Research Purpose

This study is conducted to evaluate feasible subsidy plans for the metropolitan area of Panama. With over 532 thousand employees, this area is where all the economic activity of Panama is concentrated. In the last four years the metropolitan area has presented many changes in its transport infrastructure and systems. The implementation of a new urban public transport systems to work along with the new metro line are some of the projects developed by the authorities. To obtain a full integration of the systems and reduction of some of the most common transportation problems that this city faces, this study proposed the development of different subsidy plans that will not only contemplate the benefit to the operators, but also the users welfare. The evaluation conducted will propose the best alternative to distribute the government budget and to give some guidance for the policy makers to determine if the subsidy plans are effectively and efficiently used or there are other alternative that could be implemented.

The research propose and contribution are given as follows:

1. Evaluate the subsidy plans implemented in Panama.
2. Propose, feasible subsidy plans that promote the integration of fare between modes and the distribution between the elderly, handicaps and review the former distribution.

3. Provide, information about the different benefits of each plan proposed and the repercussion of their implementation.
4. Provide, suggestions of the implementation of transit subsidies for futures plans.

## 1.3 Research Scope

### 1.3.1 Transportation System

Transit subsidies can be granted to different types of transportation modes. The subsidy plans proposed in this study will be directed only to urban public transport (MRT and bus), since these are two main transport systems in Panama.

### 1.3.2 Geography Scope

The study is conducted in the metropolitan area of Panama, important center of the economic activity of the region. This area is located in the providence on Panama and is distributed in four districts: Panama City; capital and largest city of the country, San Miguelito, La Chorrera and Arraijan (see figure 1). The total population is 1.5 million of inhabitants, which represents 48% of the total population of the country, distributed in an area of 2,561 km2. 2 million of trips occur every day as a result of the 532 thousand employees distributed in the area. The principal transport modes used are public bus 50.3%, private car 16.9%, walking 19.9%, and taxi 12.9%.

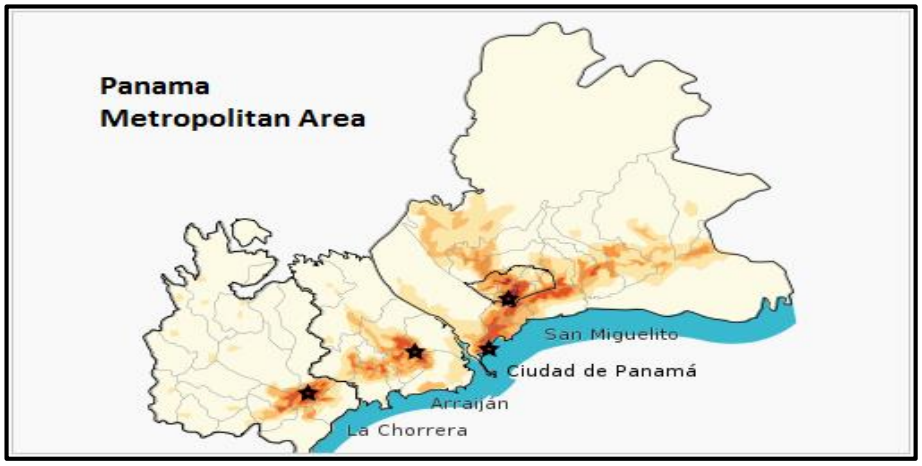



Figure 1 Panama Metropolitan Area
Source: Panama National Survey Department

### 1.3.3 Time Scope

The data used to evaluate the different subsidy plans for Panama was collected in a five years period from 2008 to 2013. The information was provided by the Ministry of Economy, National Institute of Statistics and Census and Finance and the Transit and Transportation Authority of Panama.

### 1.3.4 Research Object

In transportation there are different types of subsidies based on the objectives. This study deals with: demand side and supply side subsidies for operators and users. Subsidies provided to manage congestion or other type of transport externalities are excluded from the study. It is important to mention that the study do not contemplate any other strategy that can be uses along with the subsidies, such as deregulation or fare structure change.

## 1.4 Research Development

The research is divided into five chapters. Chapter 1, contains a description of the motivations of our study and a brief introduction of the scenario of Panama. Chapter 2, provides a review of relevant literature, about the type of subsidies and cases study of their implementation. Chapter 3, presents a definition of the Analytic Hierarchy Process; the method used to evaluate the different subsidy plans. This Chapter provides a description of the elements of the AHP such as; objectives, criteria and alternatives. The discussion of the results is presented in Chapter 4. The last part of the study is Chapter 5, which contains the conclusions and suggestion of the study. Figure 2 represents the research development.

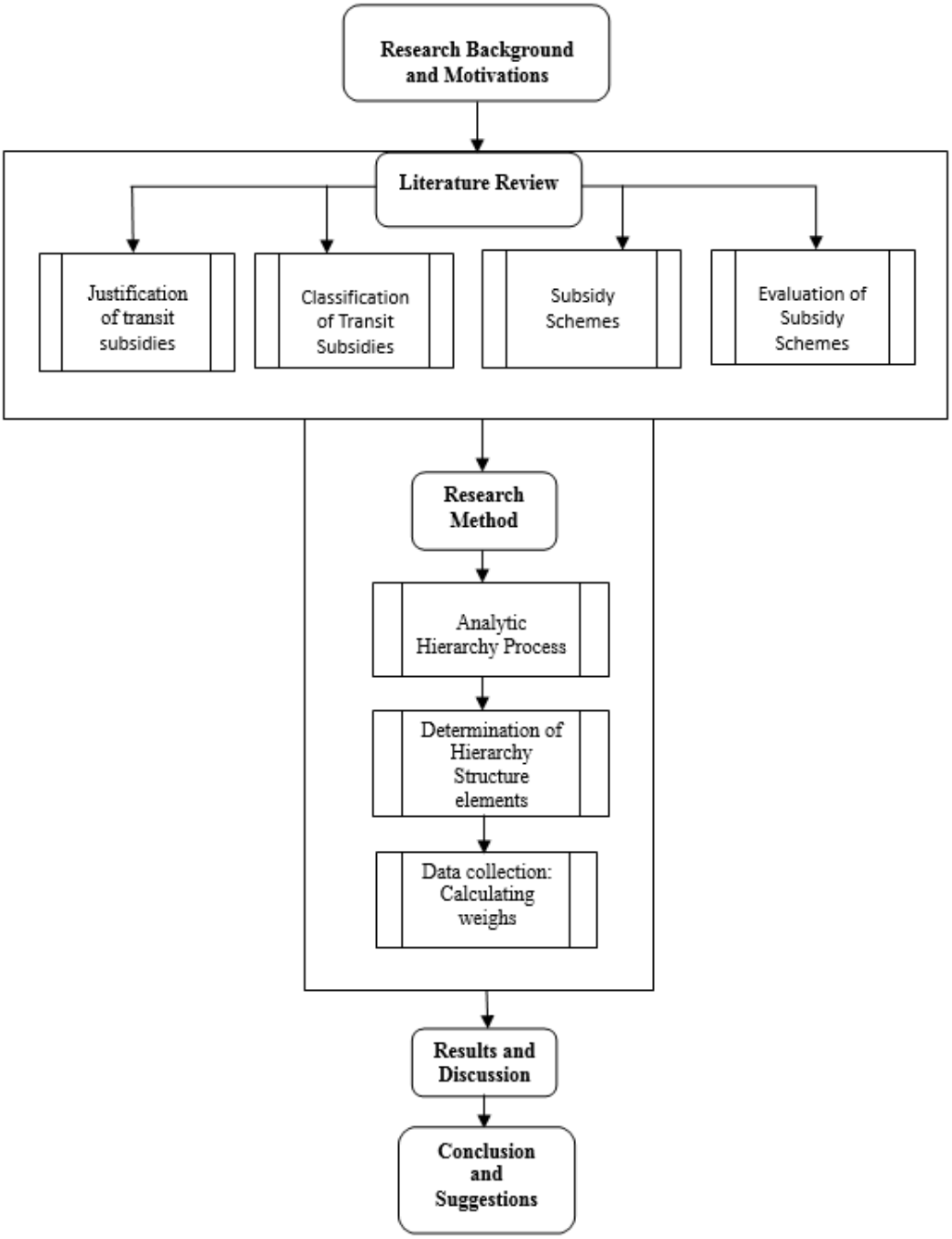



Figure 2 Research Development

# 2. Literature Review

## 2.1 Justification Arguments for Transit Subsidies

In transit economics, there are many objectives that can be achieved by using different transport policies. One of the most used instruments are transit subsidies, implemented in many countries to support transport cost, infrastructure and maximizing social welfare. Literature related to this subject offers a wide variety of definitions for this activity. In a report elaborated by the European Environment Agency (2007) two approaches were identified based on welfare economy and fiscal policy. The first, defines transit subsidies as all transport cost that are not covered by users, including all kinds of externalities, infrastructure cost or different regulations. The second approach, defines "subsidies" as only those economic advantages that are granted from public budgets that do not provide a direct service in return, e.g. grants and tax deductions (Best, 2007). In resent publications of the OECD (2005) a subsidy was described as a result of government action that confers an advantage on consumers or producers in order to supplement their income or lower their costs (Tscharaktschiew and Hirte, 2012). In Nijkamp (2002) subsidies are defined as a payment that does not required a direct exchange of goods or services of equal market value in return; it is used to accomplish a specific social objective or has a specific effect. All the definitions compiled converge in the same idea; transit subsidies are provided as an incentive to transportation users and operators with the use of different economic strategies (fare structure, concessionary fare, operating subsidies; etc.) in order to accomplish several objectives (economic, social and environmental).

It is important to recognize the reason why a subsidy is granted in the first place. This will allow the authorities to identify the benefits and possible effects of their implementation. Studies conducted on subsidies have revealed that there are many different reasons that justify transit subsidies. A major reason is to provide a form of in-kind income redistribution to persons of lesser means who ride buses. Subsides are also used to manage road congestion on unpriced roads. Bus subsidy has also been espoused for energy conservation reasons, and can be supported on the basis that public transport has an option value (Tisato, 1998). There are several different rationale for subsidizing transit generally classified as allocative efficiency, social distribution and negative transport externalities. In circumstances where policy makers believe that several of this objectives may be achieved through increasing public transport modal share,

the subsidy may be targeted at developing demand by identifying marginal segments of use (Gwilliam, 2008). In the following part of this study we will define the different rationale for subsidizing.

### 2.1.1 Allocative Efficiency

There are three different approaches for the argument of allocative efficiency of transport subsidies. The first approach is based on welfare maximization and utility pricing. The starting point thus tended to be a presumption that welfare would be maximized with prices set equal to marginal cost (economic rule in price setting for an efficient allocation of resources). Hence, if average costs are falling the presumption would be that optimal prices would not cover total cost and subsidy would be necessary in order to maximize welfare (Gwilliam, 2008). The study conducted in Nijkamp (2002) provided a clear demonstration of this situation, in the case that price is set equal to the marginal cost, public operators will incur in loss, because marginal cost is less than average cost. Price discrimination is possible, but may not be practical. It is clear that funds must be raised from somewhere to keep these operators in business.

The second efficiency argument is based on the existence of user economies of scale, the "Mohring effect"; first describe by Herbert Mohring in 1972. Its describes that when the cost of waiting time is included as an input to the production of trips, public transport services are subject to economies of scale. This means that as public frequencies increase, waiting time decrease, demand increases, and frequency increases again. In other words the Mohring effect explains that the access cost or waiting time incurred by passengers decreases when public transport provision is increased (Behrendt et al., 2010).

The last approach is the argument relating to the theory of the second-best, based on the increase in private car use and patronage. In the study conducted by Gwilliam (2008) is explained that as private automobile ownership and use grew in the sixties and seventies, transit systems, which had traditionally been commercially viable began to suffer patronage loss and consequent decline of service. This led to consideration of the efficiency implications of this trend, and based on the theory of the second best, generated the argument for subsidy to compensate for miss-pricing of a complementary or competing good. The reason described in Gómez-Lobo et al. (2009) is that the users of these alternative mode (private car) do not pay the full cost they

impose on society, in terms of infrastructure use, pollution, congestion, road safety risk and other environmental externalities. They are thus being subsidized. Therefore, by subsidizing public transport, competition between these alternative modes is placed on a level playing field and improves resource allocation.

### 2.1.2 Social Distribution

The second argument we are going to discuss is related to the social purpose of subsidies, based on the redistribution of income to certain less privileged groups. Transit subsidy transfers real income in the form of transit service rather than cash. Some groups in society, which are largely dependent on this service, will benefit from this subsidy (Nijkamp, 2002). This is the case of some parts of Europe, such as the Netherlands, and Brussels who has implemented free transport for students (Cees van Goeverden, 2006).

### 2.1.3 Negative Transport Externalities

In many countries transport use give rise to significant problems, which are expected to grow even worse in the future if no counteracting measures are taken (Mayeres, 2000). These problems often defined as negative transport externalities; such as congestion, accidents as well as local and global air pollution, can be alleviated by urban public transport use. Subsidizing public transport may thus be a second-best policy tool for addressing these problems (Behrendt et al., 2010).

Table 1 contains the main description of the justifications of transit subsidies and the studies related to that matter for a better understanding of the literature.

Table 1 Justification of Transit Subsidies

| Justifications | Description | Studies |
|---|---|---|
| **Allocative Efficiency** | Welfare maximization and utility pricing.<br>Existence of user economies of scale, the "Mohring effect".<br>The theory of the second-best, based on the increase in private car use and patronage. | (Nijkamp, 2002), (Gwilliam, 2008), (Behrendt et al., 2010) |

| | | |
|---|---|---|
| **Social Distribution** | Social purpose of the subsidies, based on redistribution of income among groups, such as those on low incomes, the elderly, or disable. | (Cees van Goeverden, 2006). |
| **Negative Transport Externalities** | Transport use give rise to significant problems, which are expected to grow even worse in the future if no counteracting measures are taken. | (Behrendt et al., 2010), (Mayeres, 2000). |

## 2.2 Classification of Transit Subsidies

Type and classification of subsidies differ from many studies. In Best (2007) subsidies are classified by "incidence" and by "mode". The term "incidence" refers to who or what initially receives the subsidy. Meanwhile, Pounds (1980) stated that subsidies are generally classified according to whether they are provided to assist in general operation of a transport undertaking (operating subsidy), or to pay for replacement or extension of the infrastructure involved (capital subsidy). Both of this studies are based on the recipient. Moreover, Gómez-Lobo et al. (2009) provides a more extended classification of subsidies. The research explains that subsidies can be classified along many dimensions according to who receives the financial transfers, the targeting mechanism used to distribute benefits and how they are funded. This information allow us to conclude that transport subsidies can be classified according to the following questions: Who is the beneficiary of the financial aid? Who bears the cost of financing the transport subsidies? What is the strategy used to target and distribute the subsidies? And what are the different funding sources? The following part of our study will provide the answer of these questions, using two main subsidy categories: Supply and demand side subsidy, both categories based on the principal recipient.

### 2.2.1 Demand Side and Supply Side Subsidy

Based on the main recipient or beneficiary of the grant we can identify two categories of subsidy, as it was mention before (Gómez-Lobo et al., 2009). The first category identified as demand side subsidies, are those provided directly to public transport users. These grant are targeted to benefit the users by group, providing direct financial support.

Supply side subsidies, are those financial aids channeled to transport suppliers (operators). This category is divided into capital and operating subsidies. Capital subsidies are those delivered to support cost of infrastructure or equipment purchase, meanwhile operating subsidies are directed to cover expenses related to the operation (revenue losses and reduce fare). These types of subsidies are based on the direct and indirect beneficiaries of these grants, it is important for the policy maker to identify to whom target the subsidy. In both cases, the objective is to lower the cost of service to final users either by lowering the proportion of cost that must be funded from fares (supply side subsidies) or by lowering the monetary outlays of users (demand side subsidies) (Gómez-Lobo et al., 2009).

### 2.2.2 Subsidy Distribution

Subsidies can also be classified according to the method used to target beneficiaries. The description of some of this method can be encounter in Gómez-Lobo et al. (2009). For example, demand side subsidies can be mean tested, if some type of welfare instrument is used to gauge the socioeconomic condition of potential beneficiaries. Or they can be given to certain categorical groups, such as students or the elderly. Another method may be to use certain self-selection mechanisms. Along the same lines, geographical targeting could also be used, targeting benefits and services to areas where the less well-off households are overrepresented.

Supply side subsidy are usually given to operators who usually do not discriminate between different types of users, therefore are less target than demand side subsidies. A solution to this problem could be the implementation of conditioned operating subsidies based on the performance or specific services. Distribution of subsidies among the population or modes are commonly used by policy makers to obtain the most beneficial subsidy scheme.

### 2.2.3 Subsidy Funding

The last classification is based on the methods used to finance subsidies. In most countries, support for public transport has traditionally been financed from general taxation. The federal or local authorities collect the revenues from various taxes, individual and corporative taxes being the biggest sources. One of this funding methods described by both studies is cross-

subsidy. This type of subsidy occurs when revenues in excess of cost for one group are used to finance deficits incurred for other groups (Nijkamp, 2002).

Table 2 provide examples of supply side and demand side subsidies based on the previous classification. The Following part will provide a description of each subsidy.

- **Subsidies to cover operating cost**

Public transport operators receive a direct transfer from the government to maintain low fares. Funded by general taxes, this type of supply side subsidy can be conditional or unconditional. In a conditional subsidy the levels of subsidy will depend on the patronage and performance of the transportation system. The performance measures most commonly used in the allocation process of these subsidies are: ridership, efficiency (cost per some service unit), local support and service expansion (Marshment, 1998). This is taken as a measure to motivate operators to maintain or improve their service quality. On the contrary, an unconditional subsidy is given to operators, with scant performance conditions in which deficit is covered by governmental aid.

- **Capital Subsidies**

Capital subsidy can by direct or indirect. This supply side subsidy can be provided has an assistance with land acquisition for operators, vehicle replacement and fleet expansion. A report conducted by Marshment (1998) implies that capital subsidies have the purpose of increase capacity.

- **Fuel tax rebate**

Operators receive a rebate on tax paid for fuel from the government. The measure is taken as a form of operating subsidy to reduce the price of fuel, since it represents a significant portion of the total operating cost. This subsidy is not conditioned on specific performance targets (Gómez-Lobo et al., 2009).

- **Concessionary fares**

Directed to certain groups of people such as children, pensioners, disables, and occasionally even unemployed people, are usually entitled to discount, in some cases zero, fares on most forms of public transport. Provided to enhance social distribution, reduce exclusion and improve accessibility of transportation systems to low income users.

Offering concessionary fares to certain groups of passengers is likely to result in additional trips being made. “The trip generation factor” used to measure the ratio of the number of trips made at concessionary fares with the number of trips which would be made by the dame people if they were charged full adult fares, explains that generation factors for bus travels vary between 1.2 to 1.9 for flat fare and 1.2 to 1.5 for half fare schemes (TRL, 2004). However, in some cases the implementation of these schemes may lead to a large increase in public expenditure. The impact on the operator vary according to the change of behavior of the users using the new discount (Baker and White, 2010).

- **Infrastructure Grant**

Subsidy commonly used in systems implementation and expansion of transportation projects. Is provided directly from government budget without users having to pay for this investment through fares. This subsidy is applied for rail or metro projects and road infrastructure.

Table 2 Classification of Transit Subsidies

| Transit subsidy | Definition | Study |
|---|---|---|
| **Subsidies to cover operating cost** | Supply side subsidy, founded by general taxes. This type of subsidy can be provided with a condition such as: ridership, efficiency, subsidy per revenue mile, cost per revenue mile and subsidy per passenger. | *(Gómez-Lobo et al., 2009), (Marshment, 1998), (Pounds, 1980).* |
| **Capital Subsidies** | This supply side subsidy can be provided has an assistance for land acquisition for operators, vehicle replacement and fleet expansion. | *(Gómez-Lobo et al., 2009), (Bergstrom, 2000).* |
| **Fuel tax rebate** | Operating subsidy to reduce the price of fuel. This subsidy is not conditioned on specific performance targets. | *(Gómez-Lobo et al,. 2009)* |
| **Concessionary fare** | Demand side subsidy directed to a specific groups for a social purpose. It can affect: trip generation, equity, affordability, and an increase in public expenditure and revenue forgone for operators. | *(Cees van Goeverden, 2006), (TRL, 2004), (Jackson, 1975), Baker and White, 2010).* |

| | | |
|---|---|---|
| **Infrastructure subsidies** | Used in systems implementation and expansion of transportation projects. Provided directly from government budget without users having to pay for this investment through fares. Involves large expenditure on state budget. | *(Muñoz and de Grange, 2010), (Tisato, 1998).* |

## 2.3 Subsidy Schemes

Subsidy schemes are the different programs undertaken by the authorities for the effective allocation of subsidies, in both demand and supply side. These programs are widely used in many developed and developing countries and vary depending on the objective of each scenario. Subsidy schemes can be given as a direct transfer to users, such is the case of some parts of United States where transit agencies offers travel passes at a discount to employers to encourage staff to commute by different modes other than the car (Potter, 2003). Other programs are directed to cover public transport operating cost. In Taiwan bus carriers from deficit routes receive a direct subsidy and tax exemption from fuel and license plate, to help them resist their financial difficulties and reduce operating cost; all part of a program called *the five-year enhancement of mass transportation program* (Lan, 2005). However, schemes differ not only in their recipients, but also in the way they are financed as it was explained before. An example of this is the flat fare or zonal fare structure presented in most American transit systems, where a type of cross-subsidization is presented in which, passengers pay the same fare regardless of distance. An study conducted by Pucher (1981) of different bus systems in San Diego, Oakland and Los Angeles found that longer trips were less profitable and only covered a percentage of operating cost through fares; causing an intervention from the government to cover the deficit.

With the use of these programs, authorities proposed to provide a high quality service to attract more private vehicle users and address environmental and traffic congestion problems (Wang et al., 2006). In most of the cases these programs are implemented because of the social benefit of providing affordable transport service to lees privileged groups; *concessionary fares schemes* generate an increase in quality of life and reduction in social exclusion amongst the poorer pass-holders (Rye and Mykura, 2009). This type of subsidy scheme is commonly used in many European cities and countries, where a discount of 46% or 100% (free travel) in fare is given to older passengers and children. The concessions are introduced as a social policy requirement

by the government to private operators; carriers receive a reimbursement for revenue lost and the additional cost incurred for the increase in ridership (Rye and Mykura, 2009).

The literature reviewed of several studies provided information about the implementation of the subsidy schemes in different countries. The findings and characteristics of this studies are listed below in Table 3. Schemes such as; operating subsidies, flat rate, concessionary travel, conditional operating subsidies and fuel tax rebate, were implemented in different countries. Some of them had successful results and others such as the scheme implemented in Argentina, which failed in accomplish the objectives imposed, been more effective the implementation of a different plan.

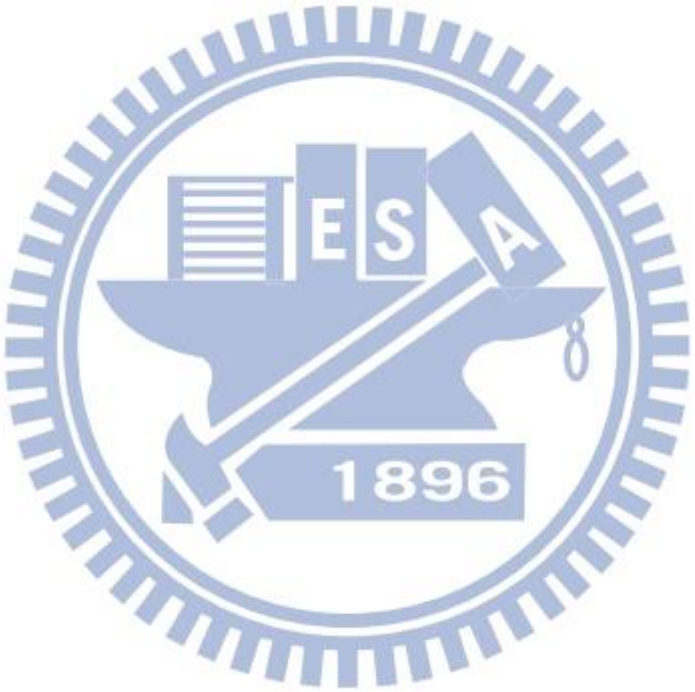


Table 3 Subsidy Schemes: Cases

| Study | Scheme | Findings | Positive/Negative Impacts |
|---|---|---|---|
| *(Lan, 2005), (N. Estupinan, 2009).* | **Operating Subsidies** | ***Taiwan:***<br>• The Five-year Enhancement of Mass Transportation Program, offers a tax/fee exemption. The direct subsidy, has improved the operators' financial crises and has provided the essential money to keep the deficit routes in service.<br>• The periodical operational appraisal has ensured the transport service quality. | • Improve quality of service.<br>• Some of this subsidies are not conditioned on performance standards.<br>• Raise cost. |
| *(Cervero, 1981), (Nassi and Costa, 2012), (Hidalgo, 2003).* | **Flat Fare** | ***Bogota:***<br>• The flat fare scheme of the TransMilenio is used to cover capital investment, operation and maintenance of bus fleet and ticketing system.<br>• No direct subsidy from the government.<br>• The cost of the fare is higher than the average cost of traditionally public transport. | • Improve equity, ridership and affordability.<br>• Without direct intervention from the government could increase the cost of fare. |
| *(Metz, 2003), (Rye and Mykura, 2009)* | **Concessionary travel** | ***London:***<br>• A concessionary travel scheme offers, free off-peak travel for elderly and disable residents on buses, the Underground, light Railway and London rail services. | • Enhance mobility.<br>• Increase public transport use.<br>• Cost difficult to limit. |

| | | | |
|---|---|---|---|
| | | • Reimbursement based on compensation for revenue lost as a results of their participation in the scheme. | |
| *(Puentes, 2004)* | **Operating subsidy** | ***The United States:***<br>• System is funded by local operating subsidy, however, revenues are not enough to support operating cost.<br>• The system is presenting financial problems due to a misallocation of resources and political jurisdiction. This situation could lead to a rise in fare. | • Appropriate regulation must be implemented.<br>• Resource allocation. |
| *(Gómez-Lobo et al., 2009)* | **Conditional operating subsidy** | ***Argentina:***<br>• Based on the number of passengers transported, the gross revenues of the firm and kilometers supplied.<br>• The levels of subsidy depend on the number of passengers transported and the kilometers supplied, providing some incentive for performance improvements. | • Improve level of service.<br>• Provide some incentive. |
| *(N. Estupinan, 2009)* | **Fuel tax rebate** | ***UK:***<br>• Bus operators receive a rebate on tax paid for fuel by public transport vehicles.<br>• Refunds about 80% of taxes paid on fuel. | • Not conditioned on specific performance targets.<br>• Suggested to fuel cost variation. |

### 2.3.1 Evaluation and Implementation of Subsidy Schemes

Public transport is strongly dependent of subsidy to cover for the differences between passengers fare revenues and operating cost (Tscharaktschiew and Hirte, 2012). Subsidies are used due to its multiple benefits, been some of them reduce fares and increase frequency. Lower fares make public transport affordable and usable for low-income users, as well as passenger segments with special needs (handicapped and older people) (Tscheulin et al., 2014). The implementation of subsidies help increase public transport patronage (Cervero, 1984), in response to the mode shift, it also works as a second-best policy to reduce negative transport externalities, such as $CO_2$ emission and energy consumption. However, in some cases it experience a negative impact in the systems performance and productivity (Bruno De Borher, 2006). In fact several studies conclude that system operating costs increase as the percentage of total system revenues provided from subsidies increases (Karlaftis, 1998). Therefore to achieve the objectives of its implementation is important to consider these impacts when designing the different plans.

One of the first element to consider when designing a policy, are the objectives or goals of the policy (Tuominen and Himanen, 2007). The goals and objectives will determine, what the policy is trying to achieve. The implementation could fail if the objectives are not properly stablished. Therefore, is important to identify the main objectives of each stakeholder involved. For example in the case of the authorities: increasing ridership, set low prices, encouraging social inclusion and minimizing public subsidies or financial compensation. Operators, on the other hand will try to prefer a policy that would allow them to cover operating cost and maximize profit and building an attractive transport system. For the passenger is all about the cost and the comfort that they can get from the service EMA (2008). Transit subsidy schemes often contemplates elements related to these objectives: social, economic, financial and environmental impacts. These elements most be included in the design of the different schemes. In transportation this objectives are contemplated in the goal sustainability; defined by The World Commission on Environment and Development as the manner in which physical, social, economic and environmental needs of a community are met without compromising the ability of future generations to meer their own needs (Yeh et al., 2009).

Subsidies and sustainability holds more relation in an economic point of view. Many public transport systems around the world suffer from low productivity, high costs, and therefore a

large amount of government subsidies is needed. Public transport offers many social and environmental benefits but, it is crucial to increase productivity and reduce costs, to improve financial sustainability. Improving the financial sustainability of public transport would help realize the potential environmental and social benefits of public transport, since it would make expanded public transport service more affordable, both for the governments who provide it and for the passengers who use it (Buehler and Pucher, 2011). Therefore, elements such as environment impacts, social distribution and economic development must be in balance when subsidies schemes are designed. Each element is directly or indirectly affected by the other. The benefits and impacts of these elements can be measured using indicator. In the study conducted by Gómez-Lobo et al. (2009), different kind of criteria is selected to evaluate the affordabilty of the subsidies to obtain the best results. It is determine that criteria such as: distributive impac, productive efficiency of operators, funsing mechanism, administrative cost and transparency of the policy; should be include in the process of evaluation and desing. These elemenst consider the cost of the policy, the effect on the operators, how are they financed, if they achieve their social purpose and the transparency in the use of state funds. In the case of the operating subsidies, (Karlaftis, 1998) used three types of indicators to analize the effect of operating subsidies on transit performance. These subsidies where divided in three cathegories: effectivenes, efficiency and overall performance. The effectivenes measures how well the system meets the objectives. As Clements (1999) mention, subsidies have to be effective and achieve their objectives at minimum cost in term of their fiscal burden and efficiency losses. Efficiency, on the other hand measures the productive ability of a transit system by either the amount of output produced per unit input or the level of input necessary to produce a given amount of output. Overall performance employs financial measures to reflect the performance of transit systems. These indicators are included to evaluate effect of subsidies on elements such as; ridership, cost, subsidy level and financial performance of recipient systems (McCarthy, 1997).

Sustainability indicators are divided into, environmental indicators, economic indicators and equity (Woldeamanuel, 2012). Environmental Sustainability is one of the most important elemenst in sustainable development, measures how transit services produce any reduction of environmental impacts. The environmental indicators measure the benefits of a mode of travel in terms of its contribution to environmental protection (Woldeamanuel, 2012). Economic sustainability is concerned about the affordability, the financial equity and the resilient to economic fluctuations of transportation (O'Hara et al., 2011). This indicators measure the

economic impact of users when a policy is implemented. Social sustainability concerns with the basic needs and a good quality of life for all members of the community (Woldeamanuel, 2012). Social sustainability include elements such as social integration and equity, health and safety and the ability of meet the basic needs of people (O'Hara et al., 2011). Table 4 presents a brief description of the proposed indicators for transport sustainability.

Table 4 Evaluation Criteria

| Study | Criteria | Explanation |
|---|---|---|
| *(Gómez-Lobo et al., 2009)* | **Distributive impac, productive efficiency of operators, funsing mechanism, administrative cost and transparency of the policy** | These elemenst consider the cost of the policy, the effect on the operators, how are they financed, if they achieve their social purpose and the transparency in the use of state funds |
| *(Matt G Karlaftis, 1998), (McCarthy, 1997)* | **Effectivenes, efficiency and overall financial performance** | Effectivenes measures how well the system meets the objectives. Efficiency measures the productive ability of a transit system. Overall performance employs financial measures to reflect the performance of transit systems |
| *(O'Hara et al., 2011), (Woldeamanuel, 2012) (Wang et al., 2009)* | **Greenhouse gas emissions Pollution** | Environmental indicators measures how transit services produce any reduction of environmental impacts. |
| *(O'Hara et al., 2011), (Woldeamanuel, 2012), (Pucher, 1981), (Robin Carruthers, 2005)* | **Affordability Finance equity Transport cost Consumer expenditure** | This indicators measure the economic impact of users when a policy is implemented. |
| *(Litman, 2009) (Litman, 2013)* | **Social interaction Social equity Accessibility** | Social sustainability include elements such as social integration and equity, health and safety and the ability of meet the basic needs of people. |

# 3. Research Method

## 3.1 Multi-Criteria Decision Methods: AHP

The proposed methodology in this research is the Analytic Hierarchy Process (AHP) a multi-criteria technique used to assist in decision making problems. The AHP considers both qualitative and quantitative approaches to research and combines them into a single empirical inquiry (Li, 2001), allowing the decision makers include their experience, knowledge and intuition. This method has been used as a decision-making tool in various fields such as, economics, regional and urban planning, energy and environmental policy development and many others.

The AHP consist of a hierarchical representation of a system, in which the decision problem is decomposed into different levels according to their common characteristics. The upper level of the hierarchy structure represents the focus of the problem "The Goal"; the intermediate levels correspond to the criteria and sub-criteria, while the lowest level contains the "decision alternatives" (M. Berrittella, 2007). The main objective of this method is to determine the relative importance of each element by conducting a pairwise comparison. These comparisons are designed to reflect the relative strength of preferences and can be derived either from actual measurements or from a specified scale.

The pairwise comparison judgments in the AHP are evaluated using the Nine-point evaluation scale (Table 5), developed by Saaty (1977). The values of the scale represents the intensities of the judgments and it allows to convert the qualitative values into numerical and form the judgment matrix; used to compute the priorities of the elements. Each value is assigned based on the opinion of experts or decision makers involved in the matter.

Table 5 Nine-Point Evaluation Scale

| Weight | interpretation |
|---|---|
| 1 | Equally preferred |
| 2 | Equally to moderately preferred |
| 3 | Moderately preferred |
| 4 | Moderately to strongly preferred |
| 5 | Strongly preferred |
| 6 | strongly to very strongly preferred |
| 7 | Very strongly preferred |
| 8 | Very to extremely strongly preferred |
| 9 | Extremely preferred |

Source: (Stein, 2013)

The pair-wise comparison matrix is formulated as it can be seen in Figure 4, where $a_{ij}$ represents the pairwise comparison rating between the elements i and element j of a level with respect to the upper level. After the pair-wise comparison matrix is developed, the priorities of the elements can be estimated (Sadeghi and Ameli, 2012) by finding the principal eigenvector w of the matrix A, represented as:

$$AW = \lambda \max W \qquad (1)$$

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}$$

When the vector W is normalized, it becomes the vector of priorities of elements of one level with respect to the upper level, where $\lambda$ *max* is the largest eigenvalue of the matrix A. This process will allow us to obtain the relative weight of the elements (Saaty, 2012).

It is noted that the AHP is a subjective methodology, which relies on the opinion of the experts, therefore this method allows inconsistency in their answers. To validate every response is necessary to conduct the consistency test, which consist on calculating the consistency ratio. The consistency ratio (CR) is used to measure the consistency in the pair-wise comparison. Saaty (1994) developed values of CR for different matrices sizes: the CR value is 0.05 for 3-

by-3 matrix; 0.08 for a 4-by-4 matrix; and 0.1 for larger matrices. If the consistency level falls into the acceptable range the weight results are valid (Li, 2001).

The AHP was chosen among many methodologies mainly for its ability to consider subjective judgments as well as quantitative information to enter into the evaluation process simultaneously and provides decision-makers with better communication (S. Shang, 2004). This method allows to determine results in a simple manner using pair-wise comparison. In other words, the participation of the stakeholders is an important part of the process. The AHP offers a simple method to obtain results applying a simple a simple pair-wise comparison.

### 3.2 Scenario description: Transit Subsidies in Panama

The transportation system of Panama receive two types of transit subsidies distributed among the metropolitan area of the providence of Panama as follows: Panama City 46.9 %, San Miguelito 16.7 %, Arraijan 12.5%, La Chorrera 9.5 % and other areas 14.4 %. The main authorities grant an operating subsidy to support the price of the fuel, same subsidy provided to previous operators.

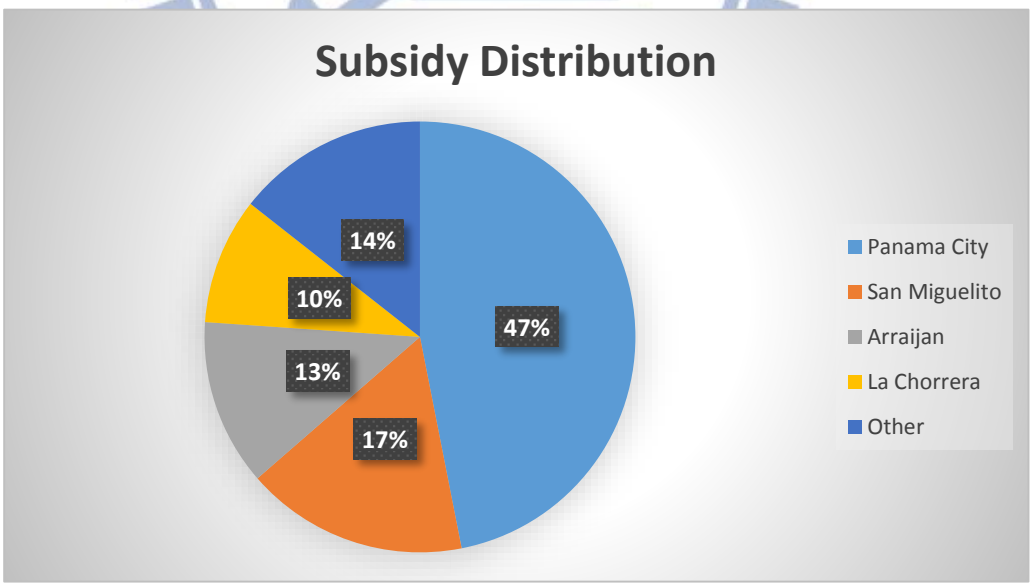



Figure 3 Subsidy Distribution
Source: Ministry of Economy and Finance Panama

The other subsidy is a demand side subsidy granted to maintain the low cost of fare. This subsidy was introduce in 2011, when the implementation of a new system threatened to increase

the cost of service. The new fare was set at USD 0.49 for passengers and USD 0.25 for students, which for the authorities represented a high cost to impose on users. Therefore, authorities decided to establish a subsidy to cover 50% (0.24 per passenger and 0.15 for students) of the total fare cost. With the implementation of this subsidy the cost of fare remained in USD 0.25 for regular users and USD 0.10 for the students. This demand side subsidy is calculated bases on the passengers per trip. Table 6 contains the subsidy annual expenditure from 2009 to the first months of 2013.

Table 6 Transit Subsidies in Panama 2009-2013 (Million USD)

| Recipient | Years | | | | |
|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 |
| **Fuel Subsidy (Diesel)** | 58.9 | 82.1 | 98.8 | 96.4 | 4.9 |
| **Fare Subsidy** | | | 8.0 | 34.1 | 23.4 |

Source: Ministry of Economy and Finance Panama

Transit subsidies in Panama are granted to prevent social exclusion of low-income households. The implementation of new transport systems required an important investment of government assets. The Ministry of Economy and Finance reveled, that for 2014 USD 50 million of the government fund are going to be directed to support the operation of the new metro line, USD 20 million of which are going to be used as fare subsidy. The main concern of the authorities is to provide an affordable transport system that would guaranty an effective distribution of resources among income classes. However, the low cost imposed on the fare is not enough to cover the operating cost of providing the service, affecting quality of service. In the last year, operators reported financial difficulties and problems with the distribution of the subsidies provided. A report released by the transit and transportation authority of Panama; authority in charge of the distribution of the subsidy, revealed that in 2011 transport services became 12.2% more expensive than the previous year causing an increase in operating cost.

On the other part, authorities are concerned about the integration of the two modes and the distribution of the subsidies. To improve this, one of the ideas is to implement new technologies for the collection of the fare, in which an integration of the two modes could be achieved by using a single card, improving the convenience of the systems and will allow to implement discounts for users using the both systems. The collection system for the fare is available for public bus and present some problems with the recharge and the availability of distribution points.

To improve distribution of subsidies between the two modes and cover operating cost, the transport authorities of Panama have decided to develop new subsidy plans that would not only represent a direct benefit for user, but will also help operators to overcome their financial problems and encourage them to improve current service levels. The new plans must proposed the integration of both systems, provide distribution between less privileged groups and provide financial aid to transport operator.

Below we have listed the main problems that the government wish to eliminate with the implementation of new subsidy plans:

- Eliminate operator financial difficulties
- Improve allocation of the subsidies between modes
- Promote the implementation of new technologies
- Improve integration and convenience of the two systems
- Propose plans for the new systems that required subsidies.

### 3.2.1 Users Patterns

The metropolitan area of Panama, receives a total of 1,715,122 daily trips, of which 35.4% are work-related trips, 39.3% study-related trips and 25.3% are made for leisure purposes. The trips are distributed among the principal modes of the city, a 50.3% (874,164 daily trips) of which are made by public bus, while a 16.9% are made by private automobile. The average number of daily trips per household in the metropolitan area is 5.21, and 4.15 motor trips. If this amount of travel is weighted by the number of household members, which is 3.9 in Panama, the average number of trips per person is 1.34, and the number of motorized trips is 1.05. A relatively low factor compared to cities such as; Chile (1.73), Lima (2.1) or Sao Paulo (1.88), which proves that the inhabitants of Panama, performed more mandatory trips due to the low level of mobility. The average number of total trips per individual is 2.17, and the average number of motorized trips is 2.05, 10 which is expected since an individual should do (in theory 10 trips) at least two trips: outbound and return. Table 7 contains the distribution of the mobility based on income groups. The groups are divided in 4 types of income.

Table 7 Distribution of Mobility by Income Groups

| Income groups (monthly income USD) | Minimum wage | Average trip per person per household. | Average trip per household | Average household size |
|---|---|---|---|---|
| less than 300 | Less than 1.05 | 1.05 | 3.35 | 3.1 |
| between 301-569 | Between 1.05-2.00 | 1.34 | 5.04 | 3.8 |
| Between 570-909 | Between 2.00-3.16 | 1.29 | 5.05 | 4.2 |
| Between 910-1475 | Between 3.16-5.09 | 1.48 | 6.00 | 4.2 |
| More than 1475 | More than 5.09 | 1.53 | 6.63 | 4.5 |
| Total | | 1.34 | 5.21 | 3.9 |

Source: The World Bank (2007)

Mobility in Panama has a strong correlation with household income. The recent economic growth of the last few years, has caused a significant increase of motorized travel. It is estimated that over 400,000 private vehicles are currently circulating, a relatively high figure for the region. The vehicle per capita of the providence of Panama, grew from 130 vehicles per 1000 inhabitants in 1992 to 208 vehicles per 1000 inhabitants in 2005; an increase of 3.7% annually, greater than the population growth. However, only 28% of households in the metropolitan area have one vehicle or more, and the average car per house is 1.4. Moreover, only 11.5% of 10 households in the low income group own one vehicle or more, while 62.5% of households in the highest income group own at least one vehicle. These statistics shows that, low income households have less access to a private car than, high income households. This first group also represents the main users of public transportation; which is the main mode to commute to work.

## 3.3 Determination of the Objectives, Criteria and Alternatives: The Analytic Hierarchy Structure

This study applies a three-level analytic hierarchy process to decompose the main problem into: the Goal; that reflect what is desired to achieve, the following level are decomposed by objectives intended to address the problem and evaluate each alternatives placed in the last level as a solution to the problem. The proposed goal for this study is to evaluate sustainable subsidy plans for Panama. Sustainable development has taken an important part in transportation planning in the past few year. Sustainability is a concept that incorporates three important dimensions: environmental, economic and social. This term is constantly employed in decision

making process; the reason is that by including sustainability in policy planning, we are considering the indirect and long-term impacts, focusing on the social welfare impacts and environment effects. Sustainability is a goal that allow us to include not only social, economic and environmental impacts; but also to consider financial sustainability in the design of the subsidy schemes for Panama. The three levels of the hierarchy structure are show in Figure 4.

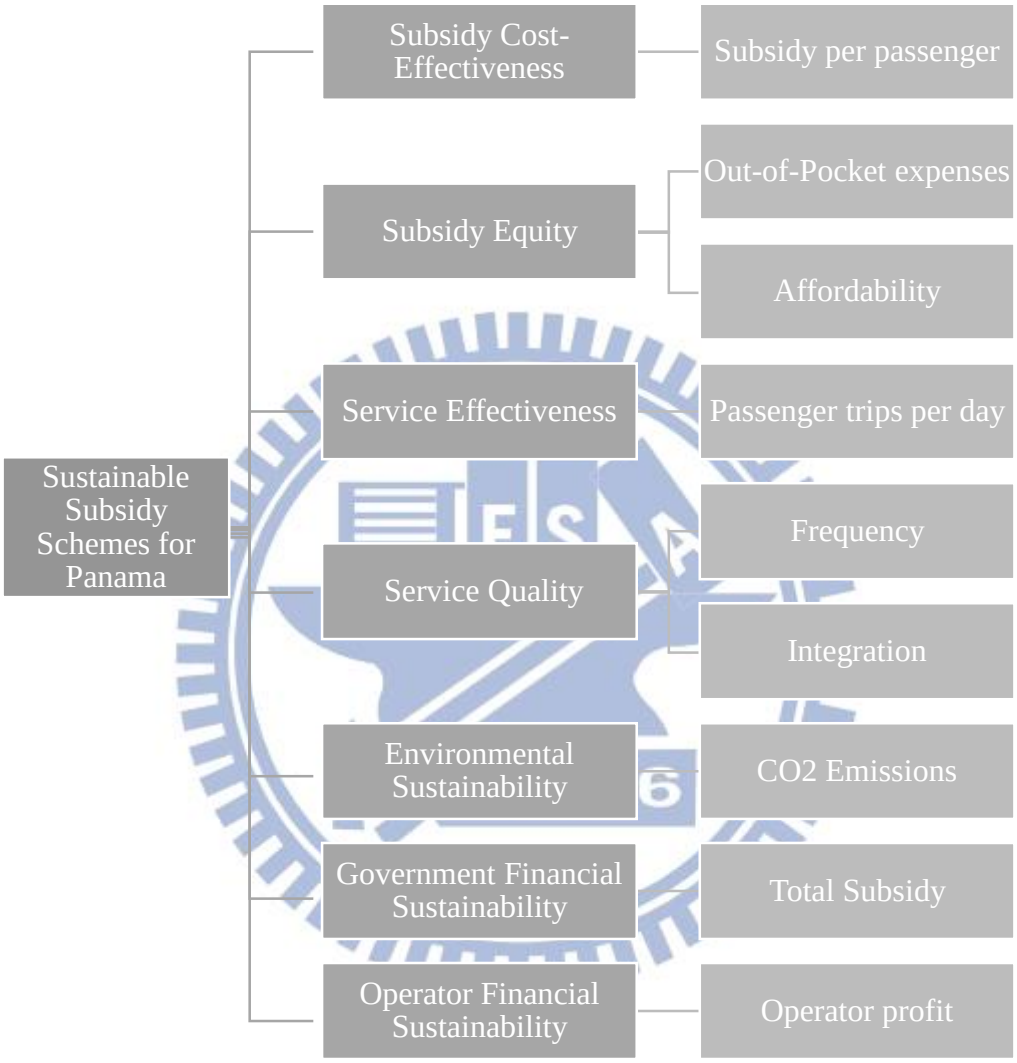



Figure 4 Analytic Hierarchy Structure: Sustainable Subsidy Schemes for Panama

### 3.3.1 Objectives-Criteria Selection

The second level of the structure represents the objectives and sub-criteria used to evaluate the different subsidy schemes. The objectives were selected based on the impacts and attributes that could present any change or improvement with the implementation of the schemes and also with the help of experts on the field of transportation and economy. Every objective is based on the premise of sustainability. The criteria used to evaluate the schemes are based on sustainable

indicators, which provide qualitative and quantitative test that serves to indicate the results of a given action. For the evaluation of the subsidies, criteria such as: Administration cost, systems financial performance, overall impacts and implications are included in the evaluation. As it was mentioned by Litman (2008) indicators of cost, equity (social) and environmental impacts must be included to provide a more comprehensive and balanced analysis. A total of 7 objectives and 9 criteria were proposed as follows (Table 8):

***Economic sustainability*** is used to evalute the performance of a given action in a business point of view. This mean how are the monetary resources being utilized? and how are being expended?. ***Subsidy cost-effectiveness*** reflect the value of the benefits obtained for dollar invested. Policy makers, should focus on expending funds in an effective maner. The proposed sub-criteria tu measure this objective is ***subsidy per passenger***, which reflects the allocation of subsidies per each passenger. Another important performance measure is ***Service effectiveness***, which conteplates the gap between service consumption and service outputs. Is the measure of outcome compared to unit of input in terms of service (Eboli, 2012). As such, these measures are a critical indicator of the success of a transit system and should be heavily relied upon when evaluating a particular system, in this case in terms of ***passenger trip per day*** measure of the extent to which passengers consume the outputs (Barata et al., 2012). ***Subsidy Equity*** relates to avoiding exclusion or reduction of trips undertaken by citizens from certain socioeconomic groups or geographical locations and concerns about the affordability of the service provided (CIE 2006). Consumption of transportation is directly affected by travelling expense (Litman 2013); in other words the fare that users paid for public transport service. For the evaluation of equity tow indicators were selected: ***Out-of-pocked expenses*** and ***affordability***. The user expenditure represents an indicator of importance of public transport modes in relation to one another, to other modes, and within total expenditure (TRL ,2004). Affordability is estimated as the percentage of monthly income or expendinture used on transport by poor families (Echenique, 2007). The affordability index is commonly used to exprese monthly income expenses by trips per moth. In a report developed for the World Bank to determine the affordability in developing countries, this index was used based on a fixed amount of 60 trips and the percentage of income per capita of the lowest income groups (Carruthers, 2005)

***Social sustainability*** concerns the impacts caused on users or the system, when a policy is implemented and their overall satisfaction. This concep usually contemplates elements such as equity, affordability, service quality; etc. ***Service Quality,*** reflect the quality of service

experienced by users (Litman, 2009). One of the most distinctive aspects used to measure service quality is frequency. ***Service frequency*** measures how often transit service is provided. It is considered an important factor in the mode choice behaviour of passengers, and the attribute with the highest weight on the overall transit service quality (Eboli, 2012). Another quality performance criteria included in the evaluation is the modal integration. This subcirteria is utilize to measure how easy is to transfer within different transit systmes (Litman, 2013).

***Environmental Sustainability*** is one of the most important elemenst in sustainable development, measures how transit services produce any reduction of environmental impacts. The environmental indicators measure the benefits of a mode of travel in terms of its contribution to environmental protection (Woldeamanuel, 2012). Generally and depending on the occupancy rates public transport produces much lower $CO_2$ emissions than private car (Behrendt et al., 2010). While petrol and diesel fuelled cars emit 130.9 g and 124.2 g of $CO_2$ per passenger kilometer, the $CO_2$ emissions from bus and coach journeys per passenger kilometer are 89.1 (Behrendt et al., 2010). ***$CO_2$ emissions*** is the indicators proposed to evaluate environmental impacts of subsidy schemes. This indicator can be measure by kg of $CO_2$ per passenger kilometer. The importance of this criteria is evaluate the ability of reduce $CO_2$ emissions and to improve the environmental performance (Bernardini et al., 2011).

***Financial sustainability*** is usually omitted in sustainability evaluation, however as (Buehler and Pucher, 2011) mention improving this element would help realize the potential environmental and social benefits of public transport, since it would make expanded public transport service more affordable, both for the governments who provide it and for the passengers who use it. This objective include both extremes government and operators. The authorities which to allocate transit subsidies to improve current inefficiencies and cover operating subsidies, and operators try to obtain support to cover their expenses. ***Governmental Financial Sustainability*** expresses the total government expenditure on subsidy to transport systems. The appropriate distribution of state funds to achieve transit improvement (Glauthier 1976). The selected criteria is the total subsidy assigned. ***Operator Financial Sustainability***. This indicator was included to measure the effect that a given policy may have on the productive efficiency of operator. In (Gómez-Lobo et al., 2009) is explained that capital subsidies increase technical change while operating subsidies reduce technical change. On the other hand, operating subsidies promote the use of more labor and fuel than would be optimal, and that capital subsidies do not wholly compensate for this effect. When receiving subsidies some firms

do not minimize the cost as a result of the incentives, which is reflected in its profits. All of these factors can be captured by considering the profit of the operators.

Table 8 Criteria and Sub-criteria

| Objectives | Criteria | Description | Study |
|---|---|---|---|
| **Subsidy Cost Effectiveness** | • **Subsidy per passenger** | The comsuption of public transportation services in relation to the resources expended. Benefits obtained for dollar invested. | *(Board, 2003)* |
| **Subsidy Equity** | • **Out-of-pocket expenses**<br>• **Affordability** | Distribution of the cost and benefits of subsidies among income classes. Impacts caused on users or the system. | *(Pucher, 1981) (Woldeamanuel, 2012), (Robin Carruthers, 2005)* |
| **Service Quality** | • **Frequency**<br>• **Integration** | Reflect the quality of service experienced by users. | *(Litman, 2009) (Litman, 2013)* |
| **Service Effectiveness** | • **Passenger trips per day** | Critical indicator of the success of a transit system. | *(Board, 2003), (Barata et al., 2012)* |
| **Environmental Sustainability** | • **CO2 Emissions** | Benefit of each modes of travel in terms of its contribution to environmental protection. Transit services produce any reduction of environmental impacts. | *(Woldeamanuel, 2012) (Wang et al., 2009)* |
| **Governmental Financial Sustainability** | • **Total subsidy** | Appropriate dsitribution of state funds to achieve transit improvement. total government expenditure | *(Glauthier, 1976)* |

| | | | |
|---|---|---|---|
| **Operator Financial sustainability** | • **Operator profit** | The effect that a given policy may have on the productive efficiency of operator. | *(P A Pienaar, 2005), (Nassi and Costa, 2012).* |

### 3.3.2 Generating Feasible Subsidy Plans for Panama

This section of the study contains the subsidy schemes proposed with the help of government authorities to improve the subsidy policy in Panama. The different subsidy schemes were elaborated using in conjunction both demand and supply side subsidies. Each subsidy scheme is developed taking into consideration the possible benefit or impact to the Government, operator and the users. For the development of each subsidy scheme the government approved USD 200.5 million of state budget, which is distributed between each type of subsidy. This budget is distributed in percentage, based on the coverage; which is set to cover 50% or more of the operating cost of the systems. In the next part of our study each subsidy scheme will be explained, a brief summary of each subsidy scheme is provided in Table 9.

***Subsidy scheme 1:***

Current subsidy plan, specified in the succession contract between the state and the private operator company (Fare subsidy), also includes a fare subsidy approved by the state (Cabinet Resolution No.15 of February 7, 2012). This plans was proposed to continue providing fuel subsidy to carriers and flat fare for overall passengers with the discount for the students. With the launch of the metro line, authorities approved state funds to develop new schemes for this system. The budget approved is directed to provide an operating subsidy to cover the operations of the metro line and a fare subsidy to support the trip cost for the new system. The budget is distributed between the different types of subsidies as follows: %50 for fuel subsidy, 20% for flat scheme and students discount, 15% for operating subsidy for the metro line and 10% for the metro fare.

The subsidy provided to fuel is intended to cover the full amount of taxes, which is subjected to the variation in fuel cost. The transfer directed to support fare of public transport is calculated by the difference between the technical fare (TF) and the fare to the public (FP) multiplied by the passengers per trip (formula 3). The fare for the public is USD 0.25 and USD 0.10 for any passenger and students respectively.

Fare Subsidy = (TF – FP) * Passengers per trip (3)

To sustain the elevated cost of the operations for line 1 of the metro, the authorities are providing a USD50 million budget (Budget approved by the Cabinet Resolution No. 062-14). As it was mention before, a 10% of this budget is going to be used to lower the cost of the fare, imposed to the users to less than USD 1 dollar; the exact value of the fare has not been revealed. The authorities recognize that this figure could increase in the upcoming years, therefore, measures used in many systems, such as advertising in metro facilities are being considered.

***Subsidy Scheme 2:***

The second plan developed proposed a concessionary fare with a discount for the main groups using the public transportation system of Panama. The plan was proposed using related studies about concessionary fare and information provided in a report elaborated by the Ministry of Economic and Finance, Evaluating Subsidies. The principal objective of this strategy is to improve social distribution of the subsidy and also encourage the use of public transport to this targeted groups. A 20% of the budget is going to be assigned to provide discount for the senior citizens, disabled and students (school and university). The operator will receive an incentive for each passenger of the concessionary scheme carried.

Another important measure taken in this scheme is to provide a capital subsidy for bus carriers to invest in fleet and infrastructure, with this the authorities decided to provide a different type of incentive to the bus carriers instead of the fuel subsidy provided in the first scheme. To help operators to overcome their many financial problems, a 25% of the state budget will be directed to cover this expenses; needed to improve the service provided.

An important concern for the authorities was to provide a convenient and easy to use transport system. Therefore to improve the integration of the system, a 25% of the budget will be provided to develop electronic ticketing for both systems. The implementation of a card, not only to improve the payment system but also to introduce integrated pricing structure between the metro and the public bus. With the introduction of the card, the payment system will be unified, which allows to manage and develop plans to integrate both fare systems. The last part is to offer a 30% of operating subsidy for the metro line.

***Scheme 3*:**

Proposed with the suggestions of three operators of the Private Company MI Bus based on the system used in Colombia (Improve distribution). Statements provided by the Panama Metro Authority. The plan was proposed to encourage carriers to improve their service a conditional operating subsidy was proposed based on the vehicle per kilometer. The operators are encouraged to improve their daily vehicles per kilometer; an incentive is going to be granted to those routes that presents an improvement. For this the authorities allocated a 30% of the state subsidy and a 20% for the fare subsidy for overall passengers and students; a supply side subsidy complemented by a demand side subsidy.

For the operations of the metro line, the authorities assigned a 25% of operating subsidy and a 25% to implement a discount fare for transfers using both system. The discount is proposed to establish a fare for the transfers lower than the sum of both. In this scheme the students will pay a 50% of the regular fare and a 30% for elderly and disabled. This will lower the price for those passengers how are using both systems to commute, allowing them to enjoy an affordable and convenient service.

Table 9 Subsidy Schemes

| **Subsidy Schemes** |
| --- |
| **Subsidy Scheme 1**<br><br>1. 55% Fuel tax rebate for bus carriers.<br>2. 20% Flat fare scheme with a discount for students.<br>3. 15% operating subsidy to cover Metro operations.<br>4. 10% Fare subsidy. |
| **Subsidy Scheme 2**<br><br>1. 20% Concessionary fare subsidy among students and elder, provided directly from government (implementing a fare discount for elder and disabled).<br>2. 25% Capital subsidies to bus carriers for investment of fleet and provision of infrastructure.<br>3. 25% Capital subsidy to develop electronic ticketing system to integrate both systems and provide transfer discounts.<br>4. 30% operating subsidy for new metro line. |
| **Subsidy Scheme 3** |

1. 30% Conditional operating subsidies based on performance for bus carriers.
2. 20% Flat fare subsidy with the discount for students.
3. 25% operating subsidy for metro line.
4. 25% Discount fare for transfers using bus and the metro system.

## 3.4 Data Collection: Determining weights using pair-wise comparison

The following step in our study is to conduct a pair-wise comparison of each element of the hierarchy structure, to determine the weights. The process was developed with the help of a group of 15 experts in the fields of transportation and economics. The experts were divided into three categories of discussion: 5 government, 5 operator and 5 professors/consultants. Each group was divided according to the main stakeholders involved in the decision making of transit subsidies in Panama and their characteristics. A questionnaire was prepared for each group, to conduct the comparison and provide a numerical value for each elements; every step is described in the following part of the study.

### 3.4.1 Experts Selection

To obtain the weight of each element the opinion of a panel of experts is required. The experts were divided into three discussion categories. The first discussion category are the five government members. These experts were chosen to represent the ideas and judgments of the government of Panama. The five experts were selected from two important institutions: The Ministry of Economy and Finance (MEF) and the Transit and Transportation Authority of Panama (ATTT). These institutions were selected based on their functions in the transit subsidy process. The MEF is in charge of the management of the state resources for the execution of the different plans and programs of the government. Therefore this institution is responsible of assigning the budget for the transit subsidy schemes. The ATTT is the authority in charge the planning, supervision and control of the transit and land operations of the Republic of Panama.

The following discussion group belongs to the private operator. The experts of this category were selected to represent the opinions and preferences of the public transport operator. The operators were included due to the fact that they are one of the principal beneficiaries of the subsidies, therefore it is important to evaluate each scheme including their opinions and

concerns. The experts were selected from MI BUS, the operating company, responsible for the design, planning and monitoring of the operations of mass transit service in the metropolitan area of Panama.

The last category represents the preferences and knowledge of five experts in the fields of economy and transportation. These consultants were selected to obtain a point of view from a partial source that could provide a balance between the two mentioned groups. For this decision group, the opinion of professors and economists, from the Technological University of Panama (UTP); the state institution of highest hierarchy in scientific and technological education of Panama and the General Comptrollership of the Republic of Panama; the institution responsible of controlling and supervise the management of the state funds. Table 10 contains the description of each expert by group, institution and experience.

Table 10 Discussion Group Information

| Discussion Group | Institution/Company | Position/Experience |
|---|---|---|
| **Government** | **Ministry of Economy and Finance** | Finance director.<br>Bachelor of Commerce.<br>Postgraduate Diploma in Management, Technological University of Panama. |
| | | National budget director.<br>Degree in Public Administration with a specialization in Project Management.<br>Diploma in Management Skills. |
| | | Assistant Regional Director of Finance.<br>Bachelor of Commerce.<br>Master in International Business. |
| | **Transit and Transportation Authority of Panama** | Department of Public Urban Transportation |
| | | Department of Finance<br>Accounting Assistant<br>Bachelor in Commerce, Accounting 20 years |
| **Operator** | **MI BUS** | Cost Analyst. 6 years of experience with MI BUS. |

| | | |
|---|---|---|
| | | Bachelor in Commerce. |
| | | Director of the Department of Finance.<br>Bachelor in Industrial Engineering.<br>Master of Business Administration. |
| | | Department of Finance<br>Accounting Assistant |
| | | Logistic operator, 6 years of experience. |
| | | Logistic operator, 3 years.<br>Bachelor in Maritime Engineering |
| **Professors and Consultants** | **Technological University of Panama** | Head of the Department of Transportation.<br>Civil Engineer. 19 years of experience. |
| | | Economy Professor, Faculty of Industrial Engineering. 17 years of experience |
| | | Head of Research.<br>Bachelor of Maritime Operations and Port.<br>11 years as professor. |
| | **General Comptrollership of the Republic of Panama** | Department of accounting and finance.<br>Bachelor in Management. |
| | | Department of accounting and finance.<br>Accounting with 16 years of experience. |

### 3.4.2 Questionnaire Development

The questionnaire was developed with relevant information about the subsidy scenario and the method used to evaluate the subsidy schemes proposed. The three main routes with more passengers of Panama were selected for the evaluation; Via España, Transistmica and Tumba Muerto. The experts were informed with the main characteristics of each route and information about the current scenario of the transit subsidies in Panama. Characteristics such as frequency, quantity of passengers, route length, headways and number of trips per day, were included in the questionnaire (see Table 11).

Table 11 Characteristics of the routes

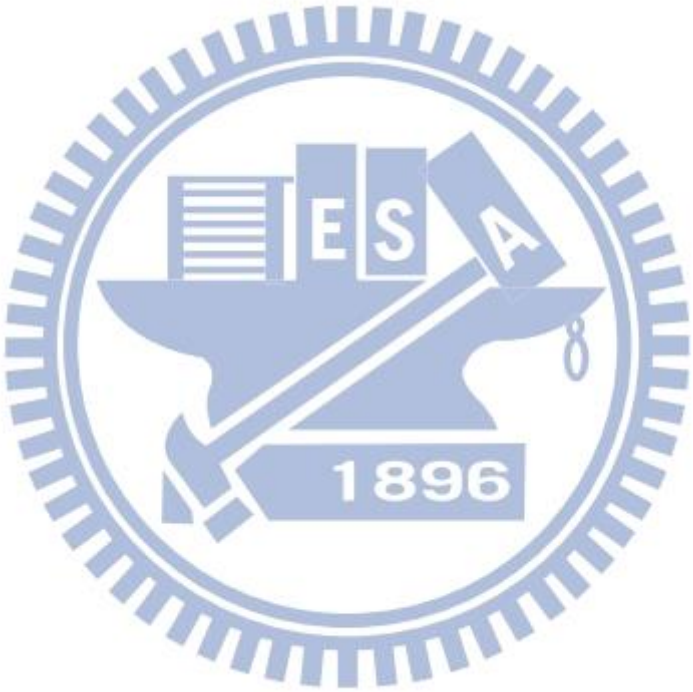
| Route | Origen | Destination | Frequency | Daily Passengers | Length (Km) | Headway | Trips |
|---|---|---|---|---|---|---|---|
| **Via España** | Tocumen | Albrook | 7 | 2,315 | 35.28 | 9 | 36 |
| **Transistmica** | Tocumen | Albrook | 5 | 1,595 | 45 | 12 | 46 |
| **Tumba Muerto** | Mañanitas | Albrook | 8 | 2,630 | 30.5 | 7.5 | 32 |

A brief description about the Analytic Hierarchy Process framework was presented along with the definition of each criteria used to evaluate transit subsidy schemes. The data of each criteria was presented to inform each respondent. This data was provided by the Ministry of Economy and Finance, the Transit and Transportation Authority of Panama and the National Institute of Statistics and Census of Panama (See Table 12). It is important to mention that since there is a legal process on the private company MI BUS, the data of the total profit for the operator will not be provided. The questionnaire was designed similar to a pair-wise comparison matrix (See Appendix 1) to enable the comparison of each element. Every discussion group provided a numerical value, based on the level of importance; presented in the nine-point evaluation scale developed by Saaty. The information provided by the experts in the pair-wise comparison helped us to determine the weights of each stage of the hierarchy structure. The following chapter of this study present a description of the results provided by the experts in the pair-wise comparison.

Table 12 Questionnaire Data

| Criteria | Description | Sub-criteria | Data |
|---|---|---|---|
| **Subsidy Cost Effectiveness** | The ability to meet the demand for transit services given existing resources. | **Subsidy per passenger** | Students: USD 0.15 |
| | | | Passengers: USD 0.24 |
| **Subsidy Equity** | Distribution of the cost and benefits of subsidies among income classes. A measure of equity, affordability which represents the portion of household expenditures devoted to transport. | **Out-of-pocket expenses** | Students: USD 0.10 |
| | | | Passengers: USD 0.25 |
| | | **Affordability** | High |
| **Service Quality** | Reflect the quality of service experienced by users | **Frequency** | See Table 3. |
| | | **Integration** | No-integrated |
| **Service Effectiveness** | Critical indicator of the success of a transit system. | **Passenger trips per day** | Via España: 83,340 |
| | | | Transistmica: 73,370 |
| | | | Tumba Muerto: 84,160 |

| | | | |
|---|---|---|---|
| **Environmental Sustainability** | Benefit of each modes of travel in terms of its contribution to environmental protection. Generally and depending on the occupancy rates public transport produces much lower CO2 emissions than private car. | **CO2 Emissions kg per passenger km** | Urban bus: 1.23 kg/per passenger km<br>Private car: 9.46 kg/per passenger km |
| **Governmental Financial Sustainability** | Appropriate distribution of state funds to achieve transit improvement. | **Total subsidy** | USD 200.5 million |
| **Operator Financial sustainability** | The amount of investment gained from produce unit system output. | **Total profit** | Profit=Farebox revenue + operating subsidy – operating cost |



# 4. Results and Discussion

After the comparison of the elements of the hierarchy structure, using the help of the experts was conducted. The results were expressed in reciprocal matrices of the components of each level against the items at the level above. To assign the weights of each criteria based on the judgments of the discussion groups, the study used a decision making software known as Expert Choice. Expert Choice is a multi-criteria decision-support software tool based on the Analytic Hierarchy Process. This tool allows the investigator to define the goals, criteria and alternatives, build the model for your decision and conduct the pair-wise comparison to determine the relative importance of the variables. To obtain conclusions based on the choices, the program synthesizes the judgments, them it allows to examine how changing the weights of the criteria affects the outcome. The different opinions were integrated based on their discussion group and the results of each criteria are displayed in the following section.

## 4.1 Government Judgments

The first discussion group we are going to evaluate is the five government experts. Each respondents was required to evaluate the different stages of the hierarchy structure and compare the elements according to the upper level of the hierarchy. The first level to be evaluated was the objectives with respect to the goal **"Sustainable subsidy plans for Panama"**. In this part the respondents were required to compare the seven proposed objectives; **subsidy cost-effectiveness, subsidy equity, service effectiveness, service quality, environmental sustainability, governmental financial sustainability and operator financial sustainability**. The results of this stage can be seen in Figure 5.


Figure 5 Goal-Objective Assessment: Government

The outcomes show that the priorities set by the government group are distributed as follows: Service quality (25.3%), service effectiveness (24.1%), government financial sustainability (16.3%), environmental sustainability (9.8%), subsidy equity (9.5%), operator financial sustainability (8.4%) and subsidy cost-effectiveness (6.7%). The distribution of each priority represents the level of importance of the presented objectives. The three first elements for the government group are; service quality, service effectiveness and government financial sustainability. This results reflects that for the government experts one of the top priorities is to improve quality service at any cost. The Authorities wish to improve the current situation and emphasize on programs that help improve the service provided by the operators. The second element is related to the consumption of the system; service effectiveness. This objective was proposed, to evaluate how successful the system is. Each implemented norm, must pose an improved in the consumption of the system. The following element, government financial sustainability, represents an important objective to consider, since the level and distribution of the subsidy depends on the state budget. The authorities pay close importance into how the money is been used and how good are the results. The two main priorities evaluated, hold a close relation in measuring how the system is provided and how is working. The difference in the priorities for service quality and service effectiveness is of 1.2%; a very tight result.

Environmental sustainability is a new concept for the transport authorities of Panama and most of the countries in Central America. However, to decrease the many transport negative externalities or impacts, the government has developed the introduction of new systems (Metro

line 1) and is in the search of new policies to reaffirm this commitment; to lower the contamination levels generated by public transport. Environmental sustainability was followed by three elements; subsidy equity, operator financial sustainability and subsidy cost-effectiveness. This elements were among the last in the priorities for the experts of this groups.

The following stage of the comparison was to assess each objective with respect to the criteria selected. In this part the respondents were required to evaluate the nine criteria; **subsidy per passenger, out-of-pocket expenses, affordability, frequency, integration, passenger trips per day, CO2 emissions, total subsidy and operator profit**, with respect to the objectives. The resulta are presented in Figure 6 as follows.

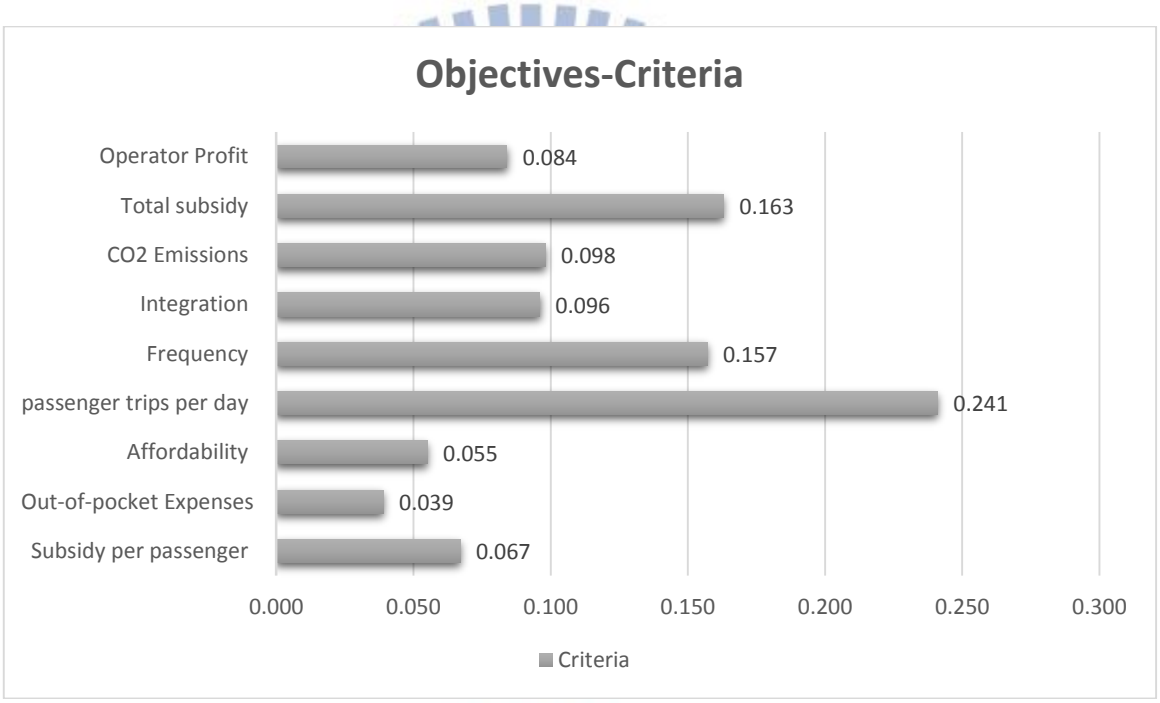



Figure 6 Objectives-Criteria Assessment: Government

The results of this stage shows that the criteria appear in the following order of priorities: passenger trips per day (24.1 %), total subsidy (16.3%), frequency (15.7%), CO2 emissions (9.8%), integration (9.6%), operator profit (8.4%), subsidy per passenger (6.7%), affordability 5.5% and out-of-pocket expenses (3.9%). This results suggest that the experts of the government group placed more interest into the criteria used to measure; service effectiveness, government financial sustainability and service quality, which prove that, although the preference distribution changed, this three elements continue to be important in every stage. An interesting fact that must be mentioned, is that the last criteria is the out-of-pocket expenses. The expenses, which are perceived as the fare, do not necessarily represent a top priority for

the government of Panama. This do not means that fare cost is not important, but there are other concerns placed first when a new plan is being developed.

The last step of the pair-wise comparison was the assessment of the three subsidy schemes with respect to each criteria. The determination of the criteria weights is a process required to obtain the ranking of the alternatives. The results are explained in the following graph (See Figure 7).

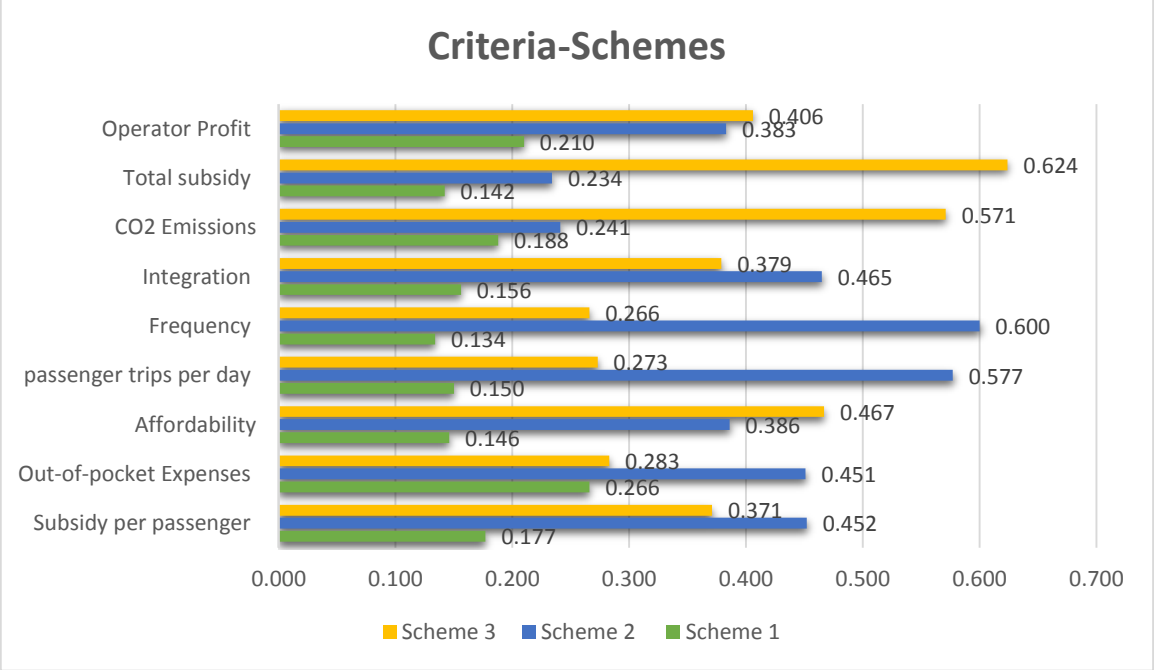



Figure 7 Criteria-Schemes Assessment: Government

For each scheme, a different weight is presented. The scheme that presented the lowest weight rates is scheme 1. Moreover, scheme 3 scored its higher weights, on the scheme 1 and 2 in four criteria: total subsidy (62.4%), CO2 emissions (57.1%), affordability (46.7%) and operator profit (40.6%). The scheme 2 presented the highest weights in 5 criteria over the other alternatives: frequency (60.0%), passengers per day (57.7), integration (46.5%), subsidy per passenger (45.2%) and out-of-pocket expenses (45.1%). The weights of each stage were used to calculate the ranking of the subsidy schemes proposed, this results are presented as follows: scheme 2 (44.1%), scheme 3 (39.7%) and scheme 1 (16.2%) as the last option (See Figure 8).

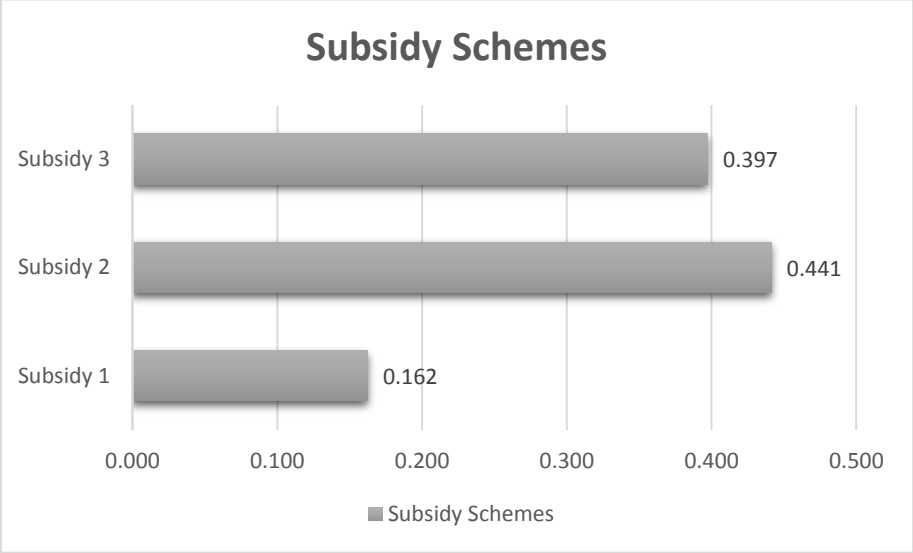



Figure 8 Alternative Preference: Government

The results presented reveal, that the best option for the group of experts from the government, is a subsidy scheme that include a concessionary fare among students, elder and disabled, with capital subsidies for carrier; instead of providing direct operating subsidies and to dispose part of the state budget to develop new technologies. This group also placed much of their importance into characteristics such as; service quality, service effectiveness and government financial sustainability. The results for this group, proved that government authorities, are selecting a scheme that would reduce social exclusion and enhance the distribution of the subsidies among the most needed; as it was mentioned earlier in developing countries subsidy is granted to provide a social benefit to user. In the case of Panama authorities, subsidies are provided to prevent any rise in the cost of public transport. Another reason, that could explain the selection of this scheme, is that it promotes the development of new technologies to integrate and improve the distribution of the subsidies. The development of an electronic ticketing, will improve convenience and speed for user, the control of the subsidies and discount for the operators and authorities; among other benefits. However the selection of capital subsidies to work without operating subsidies; for the operator, reflects the need of the authorities to place subsidies directly to the investment of fleet to enhance one of the main problems of this system, lack of supply. The results for this group are presented in the AHP framework in Figure 9.

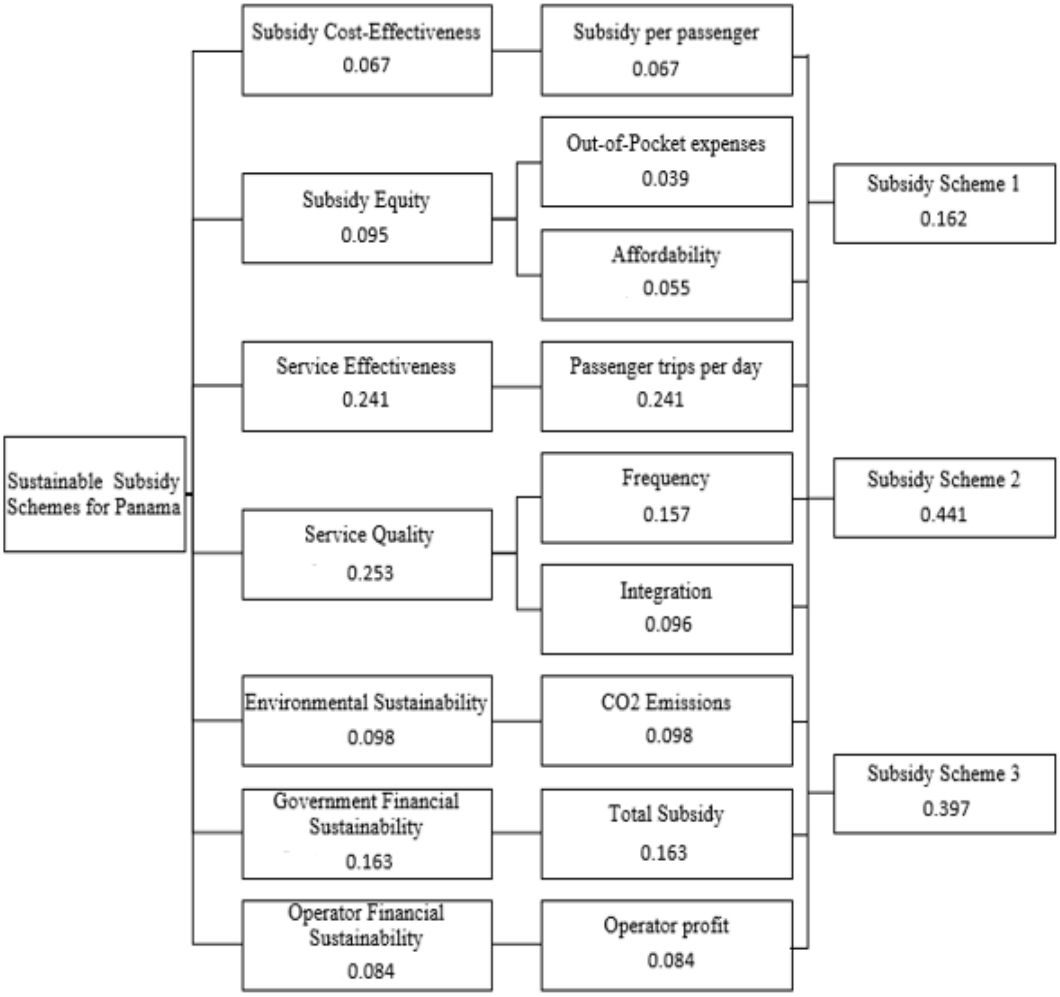



Figure 9 Government Judgments

## 4.2 Professors and Consultants Judgments

The following results, represent the opinion of the five professors and consultants selected to conduct the questionnaire elaborated. In the first stage of the evaluation; goal-objective the results (See Figure 10) are distributed as follows: Service effectiveness (22.3%), Government financial sustainability (22.2%), Operator financial sustainability (17.3%), service quality (14.9%), environmental sustainability (11.2%), subsidy equity (7.8%) and subsidy cost-effectiveness (4.3%).


Figure 10 Goal-Objective Assessment: Professors and Consultants

The group of professors and consultants acted as outside viewers. This results show that for this particular group, the evaluation of the subsidy schemes must prioritize: service effectiveness, government financial sustainability and operator financial sustainability. In other words their priorities are established on the consumption of the service and how successful it is, once the plan is implemented. Moreover, state budget must represent an important part in the decision, due to the fact that subsides depend on the amount of financial aid provided. However, this outcome not only perceives the state budget, but how subsidies affect the financial sustainability of operators. This taking into consideration that, some subsidies are provided, directly to cover operating cost and to support any financial loss of the operators.

Based on the opinions of the professor and consultants, this are the priorities for the criteria with relation to each objective (See Figure 11): passenger trips per day (22.3%), total subsidy (22.2%), operator profit (17.3%), $CO_2$ emissions (11.2%), frequency (8.1%), integration (6.8%), affordability (4.4%), subsidy per passenger (4.3) and out-of-pocket expenses (3.4%). The results suggest that the priorities set, passenger trip per day as the most important criteria of the evaluation, followed by total subsidy and operation profit. The point of view of this group shows that; as it was described in previous chapters of this study, subsidies have an important impact in the consumption of the service, also in government expenditure and operator profit. The subsidy scheme proposed for Panama, must hold a balance between this characteristics to obtain suitable outcomes. The proposed scheme should motivate passengers to use the service and also provided the necessary help for operators; at reasonable subsidy levels.

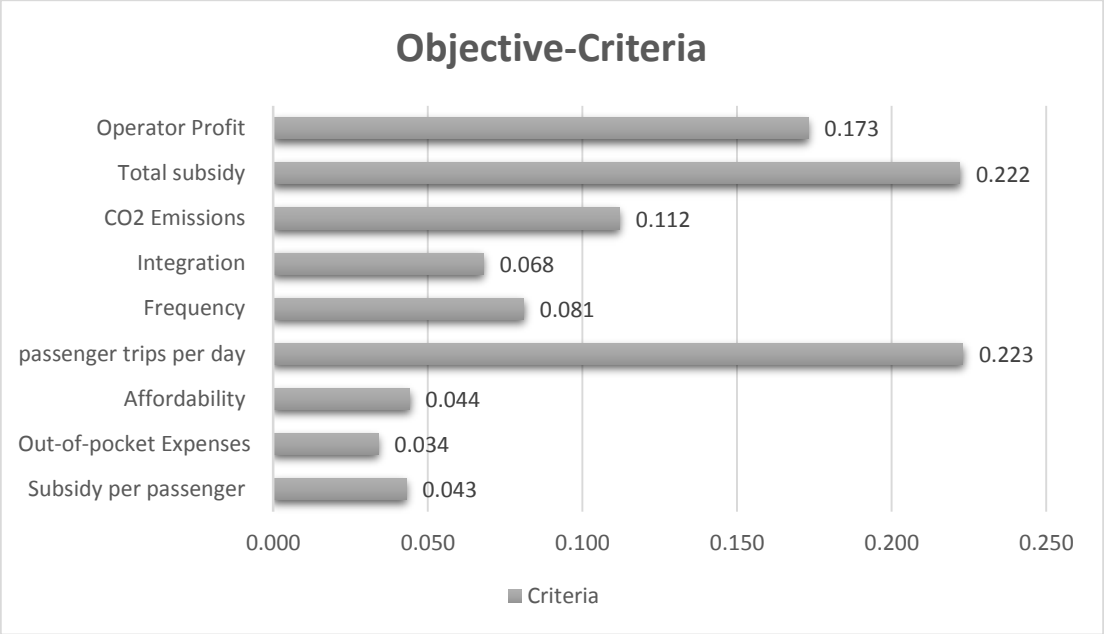



Figure 11 Objective-Criteria Assessment*:* Professors and Consultants

In the evaluation of each criteria based on the subsidy schemes proposed, the results of the priorities display that, for this group, the criteria operator profit presents a higher weights in scheme 1 (37%), followed by scheme 3 (32.4%) and scheme 2 (30.6%). The plans that presented the higher levels of priorities are scheme 3 and 2. For the last one, the highest weights are distributed in the following three criteria: out-of-pocket expenses (42.8%), passenger trips per day (36.8%) and frequency (36.2%). On the other hand, scheme 3, exhibit the highest weights in the following criteria: total subsidy (44.9%), subsidy per passenger (44.9%), affordability (40.3%), integration (40.2%) and $CO_2$ emissions (36%). The distribution of each criteria, among the subsidy schemes is presented in Figure 12.

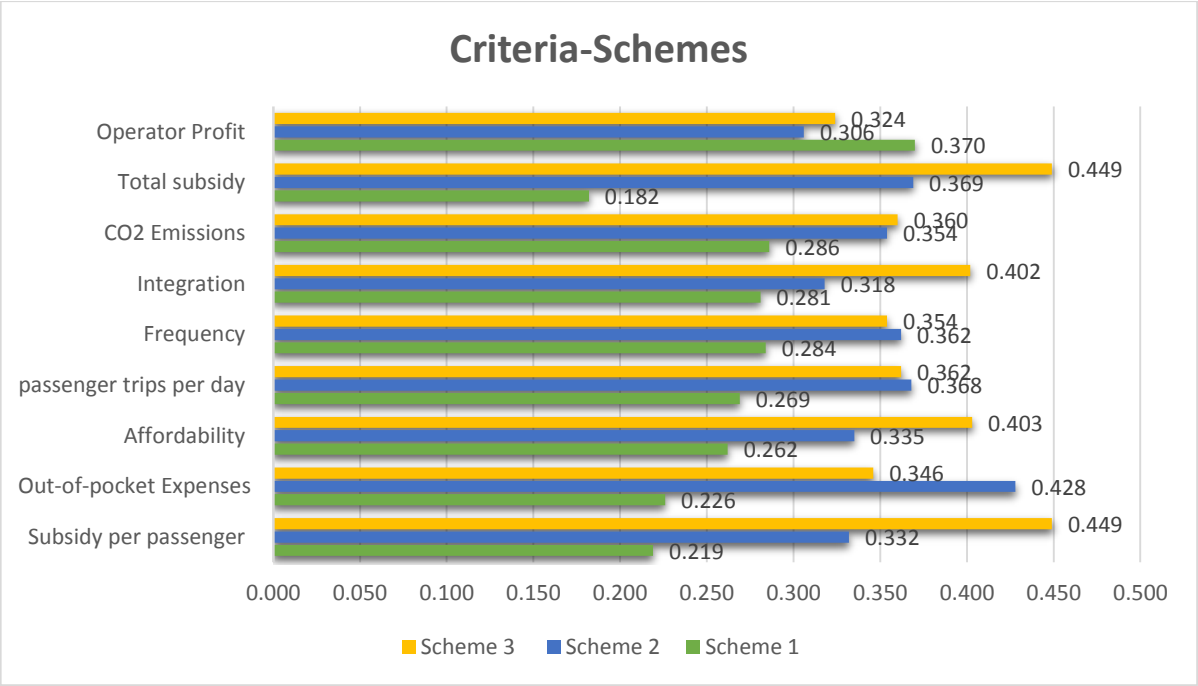



Figure 12 Criteria-Schemes Assessment: Professors and Consultants

Based on the information provided for this group, the ranking of the subsidy plans is as follows: scheme 3 (38.2%), scheme 2 (35.1%) and scheme 1 (26.7%). The findings demonstrate that for the group of professors and consultants, the best option is the plan includes the implementation of conditional operating subsidies based on vehicles per km, a flat fare system with the discount for students and a discount fare for transfers from both systems. Their opinions; based on the evaluation of the criteria with respect to the schemes, suggest that this scheme has the highest levels in five important criteria, such as; total subsidy, subsidy per passenger, affordability, integration and $CO_2$ emissions; and for these reasons it is the plan that best represents the interest of both parties (Government and Operators).

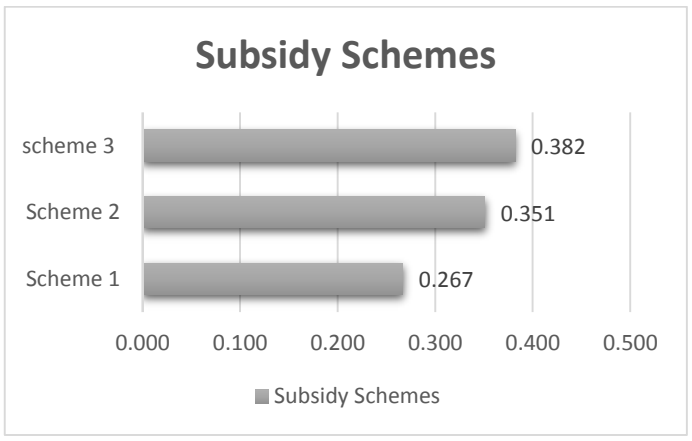



Figure 13 Alternative Preference*:* Professors and Consultants

As it can be seen, the results of this group differ from the opinion of the government authorities. The opinions were directed from a financial point of view. These experts were interested in a plan that would benefit both stakeholders, with a condition to determine their performance. The introduction of a new discount for transfers will decrease the cost in the use of both systems and will attract more passengers. With a conditional operating subsidy, the level of subsidy is controlled and the performance of the system is improved. Therefore, the experts saw in this alternative, a cost efficient measure. Figure 14, presents a summary of the judgments made by this group of expert, containing all the weights distributions among the objectives, criteria and alternatives.

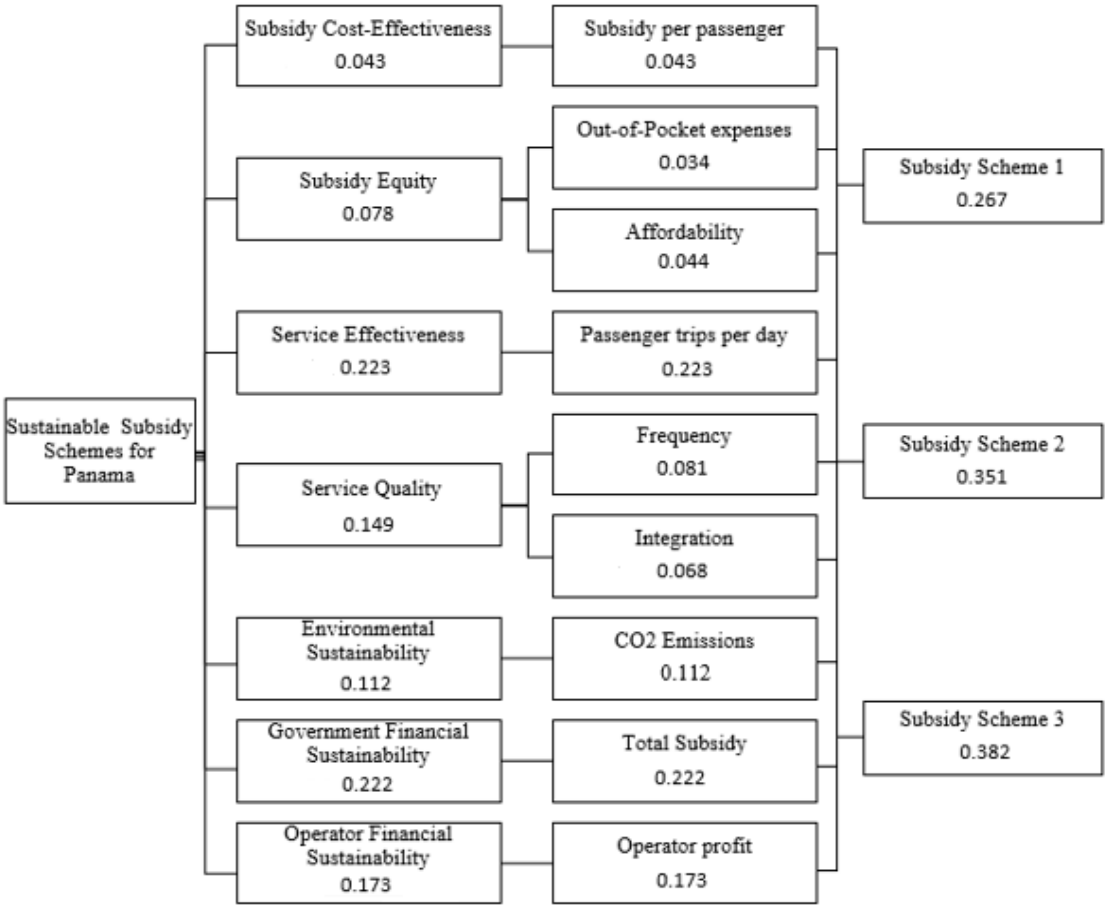



Figure 14 Professors and Consultants Judgments

## 4.3 Operator Judgments

The last group in the evaluation of sustainable subsidy schemes for Panama, is formed by five members of the private company responsible for providing the public transport service. The evaluation of this group allows us to balance the government opinions with the needs of the

operators. The judgments made by the operators in the first step; where the objectives (subsidy cost-effectiveness, subsidy equity, service effectiveness, service quality, environmental sustainability, governmental financial sustainability and operator financial sustainability); were evaluated with respect to the Goal (Sustainable Subsidy Plans for Panama). The results can be presented (See Figure 15) as follows: government financial sustainability (26.1%), operator financial sustainability (17.9%), service effectiveness (17.6%), service quality (11.4%), environmental sustainability (10.7%), subsidy equity (9.4%) and subsidy cost-effectiveness (6.8%).


Figure 15 Goal-Objective Assessment: Operator

The results demonstrate that for this group, the three most important criteria are: government financial sustainability, operator financial sustainability and service effectiveness. This prove that the most important element in the evaluation of the subsidy schemes for the operator is the level of subsidy provided by the government. The reason is that, the subsidy amount affect the profit of the operator and therefore the development of the operations. The level of subsidy will determine, the amount of help received by the government and if is enough to bail them from the financial struggles. The second important element in the priority is the operator financial sustainability. The subsidy schemes proposed must consider this as an important fact, operators choose a subsidy scheme that would represent a benefit for their financial stability, and this includes the levels of subsidy and farebox revenue. The third objective; that this group has selected is service effectiveness. The group formed by the operators is concerned about the

impacts of the subsidy schemes implemented. The subsidy scheme selected can affect performance and development of the system and these impacts can be negative or positive. Therefore, their opinion is based on the most suitable plan for the scenario of Panama.

The following evaluation conducted by the operator are the criteria with respect to the objectives. The nine criteria were prioritized as follows (See Figure 16): total subsidy (26.1%), operator profit (17.9%), passenger trip per day (17.6%), $CO_2$ emissions (10.7 %), subsidy per passenger (6.8%), frequency (6.6%), out-of-pocket expenses (5.1%), integration (4.8%) and affordability (4.3%).

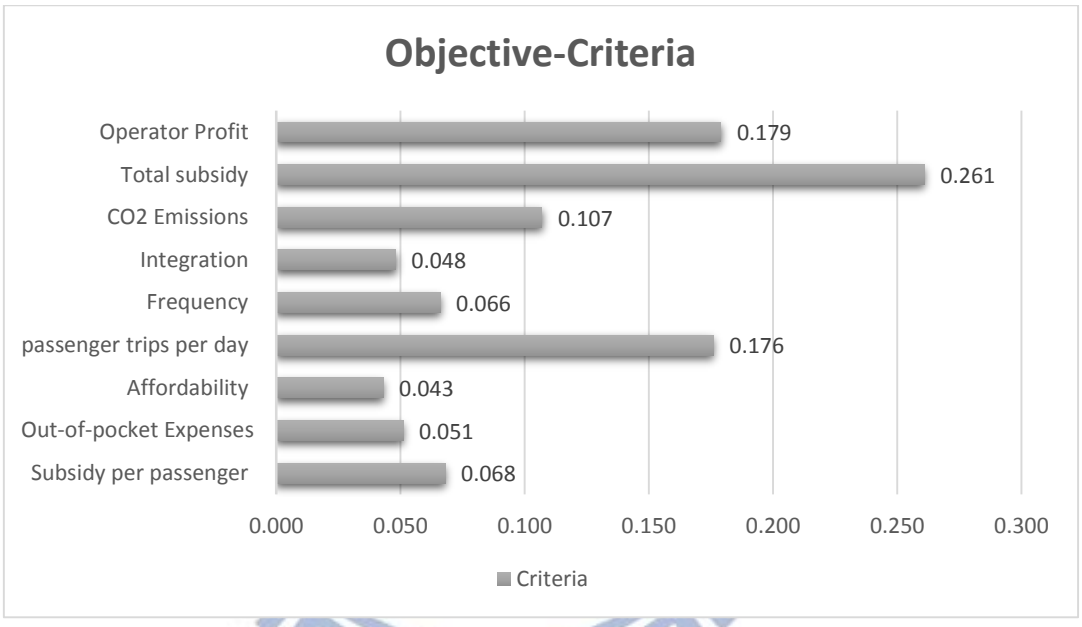



Figure 16 Objective-Criteria Assessment*:* Operator

The three main criteria for this group are the: Total subsidy, operator profit and passengers trip per day. These results reflect that the judgments made by the members of this group, placed much of its priorities in the level of subsidy provided; an important matter to consider when designing a subsidy scheme. The total subsidy, allows the decision-maker, distribute the right amount of subsidy to each category and by subsidy type (supply side and demand side); it also determined the amount of operating subsidy provided to operator. Operator profit, the second criteria in the priorities, reflects that operators gave importance to a subsidy scheme that would not affect their returns, but that it represents a benefit for their financial status. The last element, passenger trips per day, represents patronage achieved; how well the system is performing with the implementation of a new subsidy scheme.

The assessment of the criteria with respect to the schemes shows that the scheme 1 receive the highest weights in the criteria operator profit (41.6%), followed by scheme 3 (35.8%) and scheme 2 (22.6%). Scheme 3 presented the highest weights in eight of the nine criteria; affordability (62.1%), frequency (57.2%), integration (55.4%), out-of-pocket expenses (49.2%), CO2 emission (44.5%), subsidy per passenger (42.5%), total subsidy (40.5%) and passenger trips per day (37.3%). The results reflect that for this particular group the scheme 3, is the plan that provides more benefits. See Figure 17 for more details.

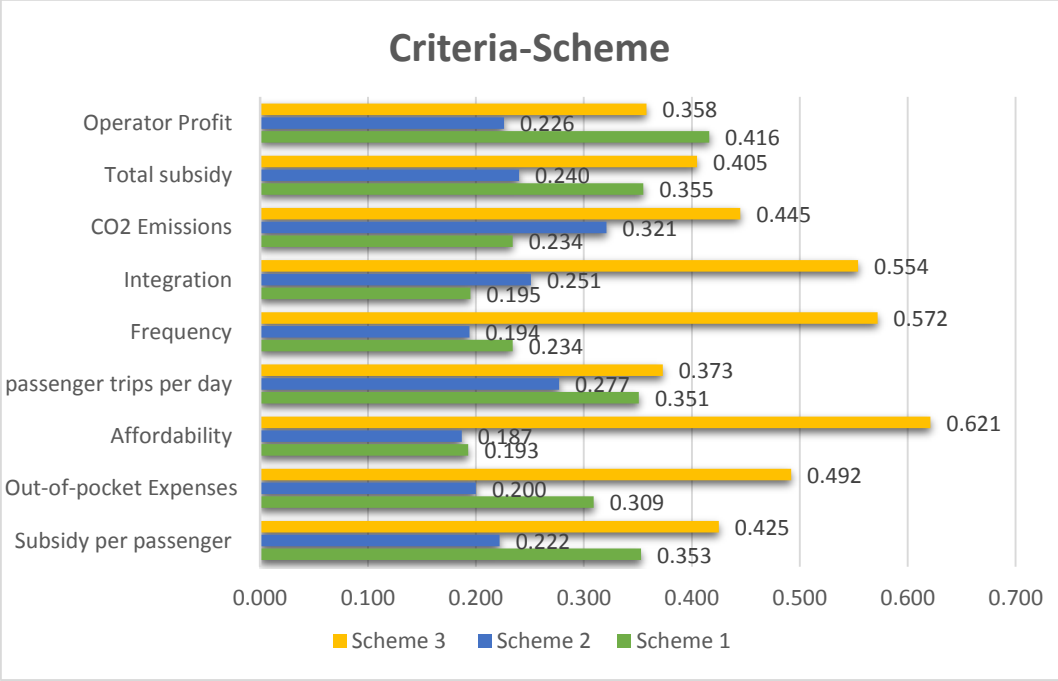



Figure 17 Criteria-Scheme Assessment: Operator

The results shared above, shows that the ranking of the subsidy plans for this group is distributed as follows (See Figure18): scheme 3 (42.8%), scheme 1 (32.7%) and scheme 2 (24.5%). For the group of operators the best subsidy scheme is plan 3 and the worst is plan 2. This demonstrate that this group, selected the subsidy scheme with the conditional operating subsidy, flat fare and discount for students and the transfer subsidy. Bases on their judgments we can conclude that this scheme represented more benefits in terms of: affordability, expenses, integration, total subsidy, frequency and subsidy per passenger.

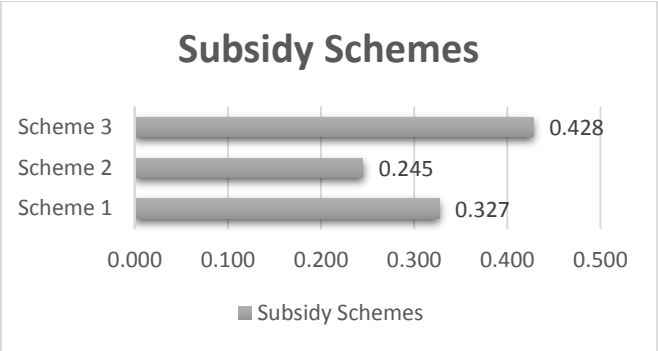



Figure 18 Alternative Preference*:* Operator

The results and the priorities of this group are presented in Figure 19. Every stage is represented with its respective weights, based on the judgments made by the five operators. The opinions of this group is similar to the one, made by the professors and consultants. Operator are more concerned in a policy that would benefit both sides. As it was mentioned earlier, this plan represents a more cost efficient option and it would help them to overcome their financial situation and enhance service quality

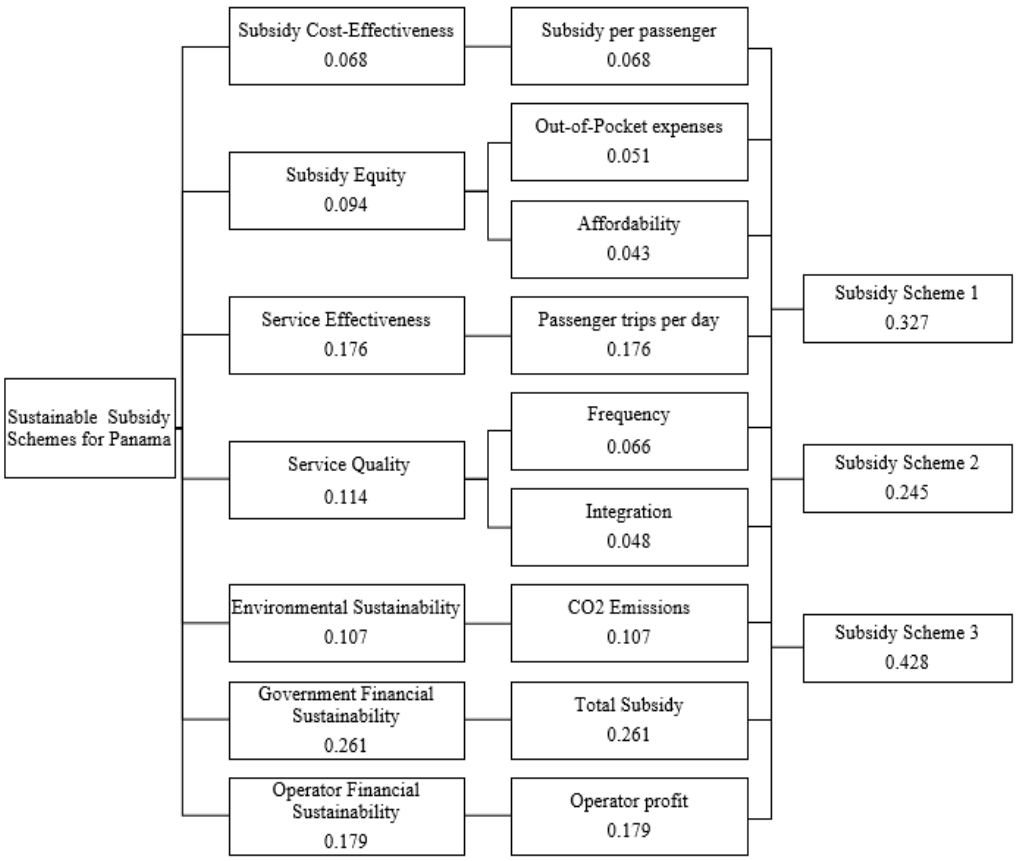



Figure 19 Operator Judgments

## 4.4 Combined Results

After the evaluation of each judgment, the result of the three groups are combined to obtain the best subsidy scheme for Panama. In this part of the study the results of each group along with the combination of the results are compared, to find similarities or disagreements in the opinions made by each expert. As it was described for each group, the first step, which consist on the pair-wise comparison of the objectives based on the Goal "Sustainable Subsidy Schemes for Panama", reveals the following results: government financial sustainability (21.7%), service effectiveness (21.6%), service quality (16.7%), operator financial sustainability (14.1%), environmental financial sustainability (10.9%), subsidy equity (9.1%) and subsidy cost-effectiveness (5.9%). The graph in Figure 20 presents the distribution the weights for the objectives.


Figure 20 Goal-Objectives Assessment: Combined results

The combined results demonstrate that the most important objective for the experts in the evaluation of the transit subsidies proposed for Panama, is the government financial sustainability, followed by the service effectiveness and the service quality. In the evaluation of the criteria with respect to the objectives, the result of the weights are: total subsidy (21.7%), passengers trips per day (21.6%), operator profit (14.1%), $CO_2$ emissions (10.9%), frequency (9.8%), integration (7%), subsidy per passenger (5.9%), affordability (4.8%) and out-of-pocket expenses (4.2%). The results are presented in Figure 21.

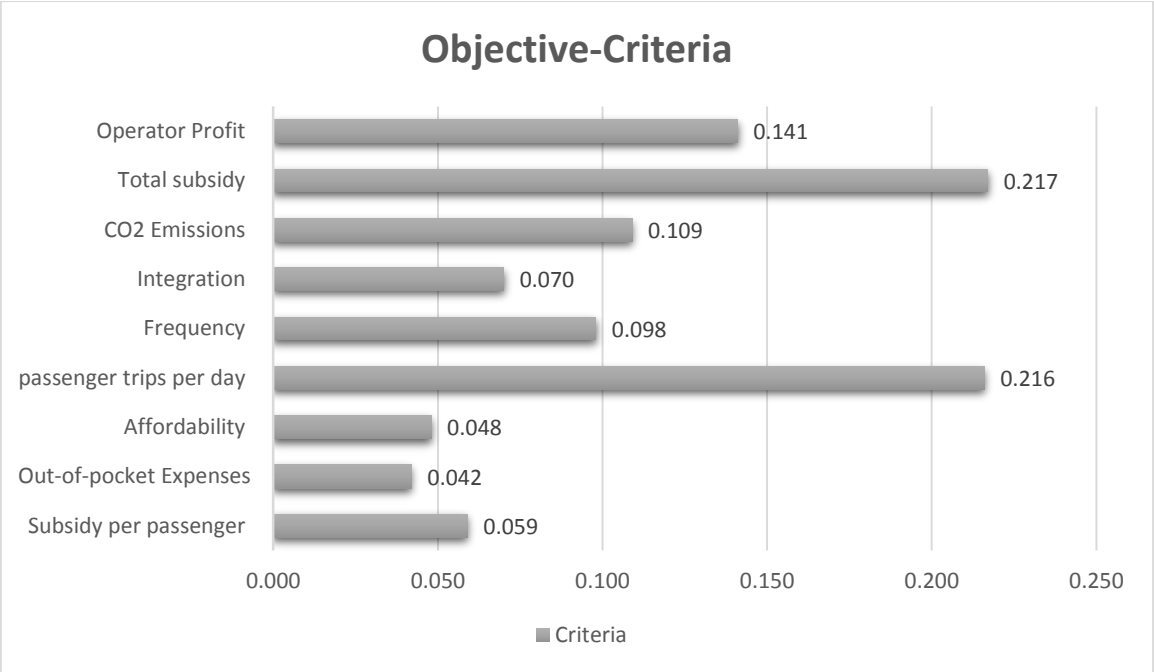



Figure 21 Objective-Criteria: Combined results

A comparison of the results obtained from each group in this stage, shows that the three top criteria selected presented a similar patron; some only vary in the position. For example, the criteria passenger trips per day, was selected in each group, however the position of the priorities change by discussion group; placed first on both groups, government and professors and consultants and last in the operator group. Another criteria listed as a priority in all the groups is total subsidy; this criteria is positioned as a first priority for the operator group and second for the other two groups. Is important to mention that the government group gave more importance to the frequency (service quality) than to the operator profit; which was placed as a priority for the operator and professors/consultants groups. This show the little importance that authorities give to operator profit rather than the effectiveness and quality of the service; which reflects their main concerns. The comparison of the results for this stage is presented in Table 13.

Table 13. Comparison of results, Criteria

| Criteria | Government | Professors/ Consultants | Operator | Combined |
|---|---|---|---|---|
| Subsidy per passenger | 6.7% | 4.3% | 6.8% | 5.9% |
| Out-of-pocket Expenses | 3.9% | 3.4% | 5.1% | 4.2% |

| | | | | |
|---|---|---|---|---|
| **Affordability** | 5.5% | 4.4% | 4.3% | 4.8% |
| **passenger trips per day** | 24.1% | 22.3% | 17.6% | 21.6% |
| **Frequency** | 15.7% | 8.1% | 6.6% | 9.8% |
| **Integration** | 9.6% | 6.8% | 4.8% | 7.0% |
| **CO2 Emissions** | 9.8% | 11.2% | 10.7% | 10.9% |
| **Total subsidy** | 16.3% | 22.2% | 26.1% | 21.7% |
| **Operator Profit** | 8.4% | 17.3% | 17.9% | 14.1% |

The evaluation of the criteria with respect to the subsidy schemes shows that, for the combined results, the scheme that presents more acceptance in most of the criteria is the plan 3, which obtain the highest weights in eight of nine elements. This suggest that if we combine the three groups, the results would show the preference for the scheme 3, followed by scheme 2 and the worst option scheme 1. Scheme 2 obtained the highest weight in the criteria, passenger trips per day (40.4%) over, schemes 3 and 1 respectively (34.5%) and (25.1%). However scheme 3 obtained the best weights in 8 criteria over the other subsidy plans: Affordability (50.3%), total subsidy (50%), CO2 emissions (45.8%), integration (44.9%), subsidy per passenger (42.4%), frequency (40.5%), out-of-pocket expenses (37.6%) and operator profit (36.9). The interpretation of the outcomes suggest that subsidy scheme 3 presents the best benefits in the majority of the elements used to evaluate subsidy schemes and it will provide the best results after its implementation. The graph in Figure 22, presents a description of the discussed results.

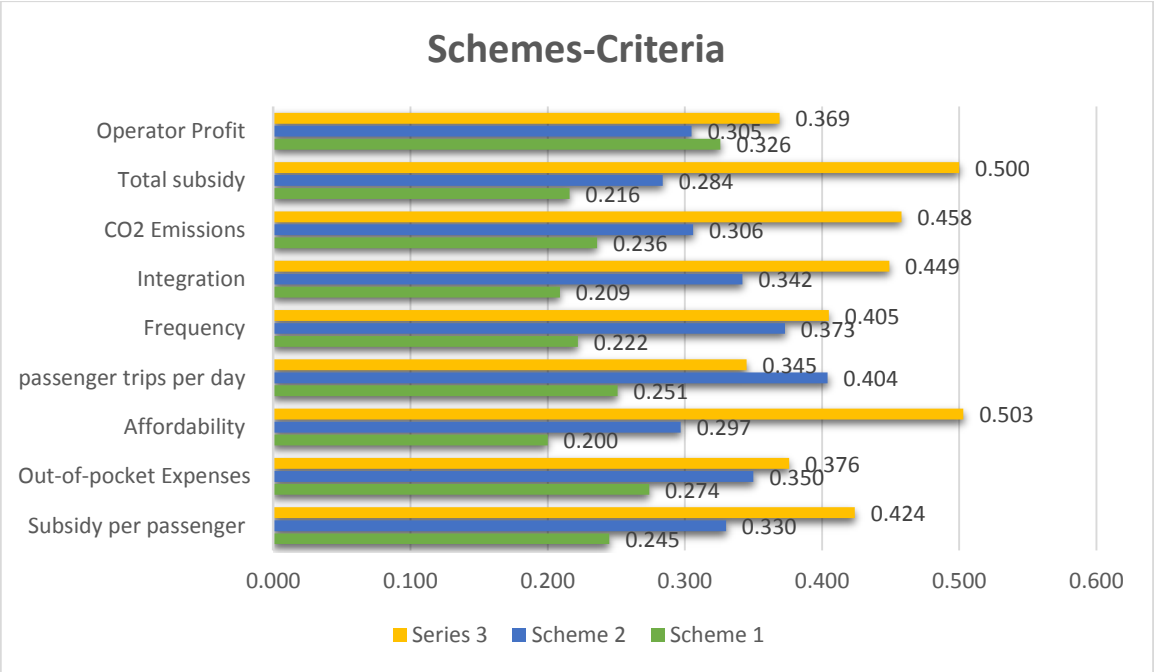



Figure 22 Schemes-Criteria*:* Combined results

The combined judgments suggest that the best subsidy pan that should be implemented in Panama is subsidy scheme 3. This plan proposes to provide a conditional operating subsidy, based on vehicles per km; to improve service quality, therefore frequency. To continue providing a discount for students and implement a discount for transfers using both systems; this as a mean to improve integration. The last incentive is directed to cover the operations of the new metro line. The distribution of the priorities for the combined results is given as follows: scheme 3 (42.1%), scheme 2 (33.4%) and scheme 1 (24.5%).

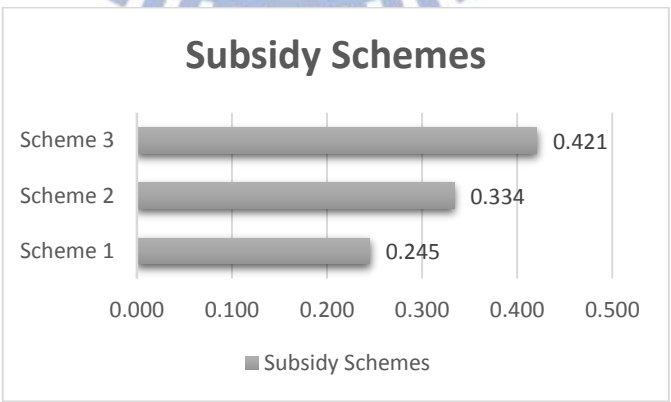



Figure 23 Alternative Preference: Combined results

For the ranking of the subsidy schemes a comparison of the results of each group was conducted. As it is shown in Table 14; the group formed by the operators and the professors, shared similar

views by selecting scheme 3 as the best option. On the contrary the members of the government group selected scheme 2 as the best option. The worst plans for this last group was scheme 1, the same as the professors and consultants.

Table 14. Comparison of results, Subsidy Schemes

| Ranking | Government | Professors and Consultants | Operator | Combined |
|---|---|---|---|---|
| 1 | Scheme 2 (44.1%) | Scheme 3 (38.2%) | Scheme 3 (42.8%) | Scheme 3 (42.1%) |
| 2 | Scheme 3 (39.7%) | Scheme 2 (35.1%) | Scheme 1 (32.7%) | Scheme 2 (33.4%) |
| 3 | Scheme 1 (16.2%) | Scheme 1 (26.7%) | Scheme 2 (24.5%) | Scheme 1 (24.5%) |

The final results of the evaluation of "Sustainable Subsidy Schemes for Panama is summarized in Figure 24.

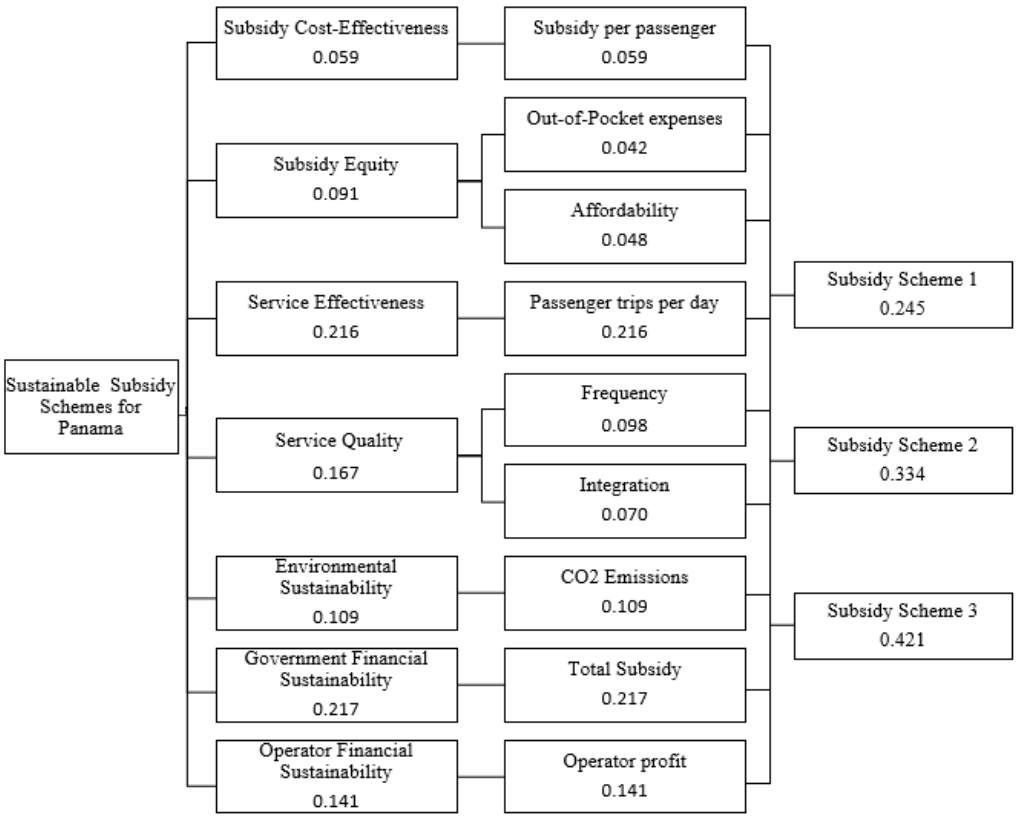



Figure 24 Final Judgments

# 5. Conclusion and Suggestions

The present study was conducted to evaluate the different subsidy programs for transit, to implement in the metropolitan area of Panama. To develop the evaluation the Analytic Hierarchy Process was employed. This commonly used method was selected for its ability to combine quantitative and qualitative judgments in the process of decision making. The AHP allows the stakeholder to issue their opinions, based on their experience about a subject and determine the best option. This method consist of a hierarchical system, where the problem is decomposed in different levels such as Goal to achieve, objectives and criteria used to evaluate the alternatives placed in the lower levels.

To determine the results, a questionnaire was developed, containing relevant information about the three main routs of Panama. Via España, Transistmica and Tumba Muerto, were the routes selected for the evaluation, since they present the largest number of passenger. Information such as, frequency, trip per day, rout length, etc. were included in the questionnaire; along with the detailed explanation of the method used to evaluate the subsidy schemes. The questionnaire was distributed among selected experts from related, public and private entities of Panama. The experts were divided into three groups: government (from the Ministry of Economy and Finance and the Transit and Transportation Authority of Panama), operator (from the private company MI BUS) and professors/consultants (form the Technological University of Panama and the General Comptrollership of the Republic of Panama).

The experts were required to conduct pair-wise comparison of the selected criteria using the verbal scale contained in the questionnaire. The members of each group were asked to compare the 7 objectives; subsidy cost-effectiveness, subsidy equity, service effectiveness, service quality, environmental sustainability, government financial sustainability and operator financial sustainability, and 9 criteria; subsidy per passenger, out-of-pocket Expenses, affordability, passenger trips per day, frequency, integration, CO2 emissions, total subsidy and operator profit.

To determine the weights of each element of the hierarchy structure, the judgments of the experts, were evaluated using a multi-criteria software called, Expert Choice. This tool allows the investigator to introduce the opinions made by each group member; based on the value of the priority scale assigned. The weights, are later used to determine the ranking of the alternatives. The results were divided in three categories of assessment: Goal-Objective, Objective-Criteria and Criteria-Scheme. According to the priorities obtained for the government experts, the three main criteria are: passenger trips per day (24.1 %), total subsidy (16.3%) and frequency (15.7%). For the professor and consultants the priorities were; passenger trips per day (22.3%), total subsidy (22.2%) and operator profit (17.3%). On the contrast the operator group presented the following weights; total subsidy (26.1%), operator profit (17.9%) and passenger trips per day (17.6%). This results suggest that, there were only a few variations in the opinions, but criteria such as; passenger trips per day, total subsidy and total subsidy were selected in more than one occasion.

The ranking of the subsidy schemes for each group presented a variation, while the professors/consultants, placed the scheme 3, first in their priority with (38.2%), the operator placed this scheme first with (42.8%). On the other hand, the government experts, placed scheme 2, as their best option with (44.1%). The selection of the scheme 2 demonstrated, that for the government, the implementation of a transit subsidy that improve social distribution of the subsidy is the best option. However, for both groups; operator and professors/consultants, a subsidy scheme based on a conditional subsidy, discount for transfers, flat fare for public bus and the operating subsidy for the metro line is the best option. Based on their results, this scheme is considered to provide the best results in terms of: Affordability, subsidy per passenger, CO2 emissions, integration and total subsidy. While, scheme 2 present the best results in: passengers per trip, out-of-pocket expenses and frequency.

To determine the final results, the judgments made by each group were combined. The combined results, exhibit that the criteria weights for the evaluation of the subsidy schemes are distributed as follows: total subsidy (21.7%), passenger trips per day (21.6%), operator profit (14.1%), CO2 emissions (10.9%), frequency (9.8%), integration (7%), subsidy per

passenger (5.9%), affordability (4.8%) and out-of-pocket expenses (4.2%). The final ranking for the subsidy scheme is: scheme 3 (42.1%), scheme 2 (33.4%) and scheme 1 (24.5%). With this results, we can conclude that the best subsidy scheme for the metropolitan area of Panama is the plan 3; which include a conditional operating subsidy, discount for transfers and flat fare. It is visible that authorities consider, that the plans implemented in 2011, are no longer effective and must be replaced.

## 5.1 Managerial Implications

The implementation of the subsidy scheme selected has some managerial implications that are explained in this part of the study. In the first place, the implementation of the subsidy scheme 3, will increase the administrative cost in the following years. The reason is that, subsidy is going to depend on the cost of operating cost, of metro line and the amount of transfers made. Another important implication for authorities, is the need of a proper regulation, to control the distribution of the subsidies among the operators. The limit of the vehicles per km must be set, with an evaluation of the performance. This in order to confirm, that subsidies are achieving their purpose.

The findings reveal that the subsidy plan implemented in 2011, is not an option for the majority of the experts. Since, the combined results demonstrate, that for the experts of all the areas, subsidy scheme number 3 represents the best benefit in almost all the criteria. This decision is contrary to the decision made by government authorities, who selected scheme 2 as their best option. In developing countries, transportation subsidies are granted mostly for their social purpose. Therefore, authorities place more important on the social objectives than on the cost effectiveness of the plans. This can be demonstrated, by the low preference of the criteria, subsidy-cost effectiveness; which describes how effective is a policy into achieving their objectives at minimum cost in term of their fiscal burden and efficiency losses. This means that autorities place more importance to plans that would be suggested to eliminate social exclusion.

On the other hand, the selection of subsidy scheme 3 as the best alternative for the city of Panama, shows that a change from a passenger per trips to a subsidy based on vehicles per km is the best option to improve the financial performance of the operators and therefore, the quali1 ty of service provided. The implementation of a subsidy based on condictions of performance, reduces efficiency problems. Scheme 3 presented the best results in almost all the criteria, including service quality. If we compare the main objectives of the authorities of Panama, it can be seen that this scheme presents the best results to achieve the collective objectives, instead of focusing on individual objectives such as, social distribution or systems cost.

## 5.2 Limitations and Recommendations for Future Research

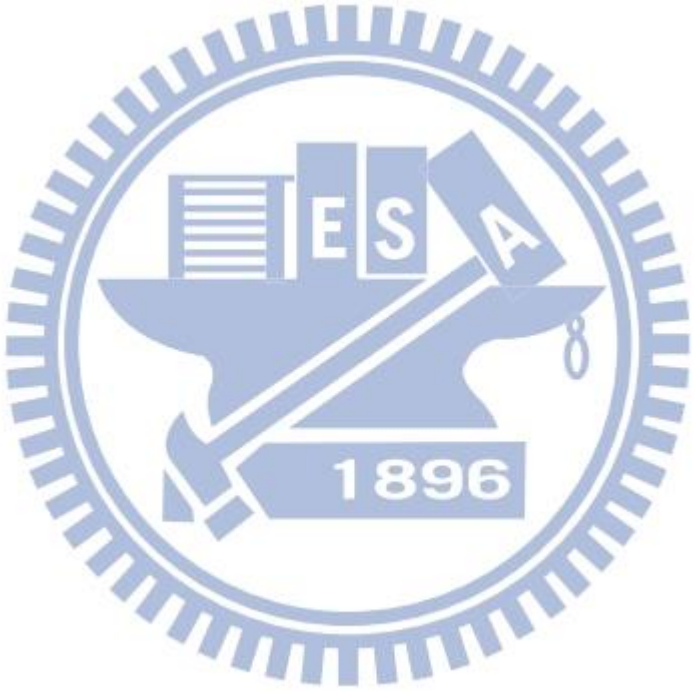
In the development of our research, we came across a series of limitations. One of the main problems was the collection of information. The most important limitations are listed below:

Data Collection: The government of Panama lacks of an institution that provides detail information regarding transportation topics and studies conducted on transit subsidies. Therefore, finding a study that would provide a more detail description of the scenario in Panama, was difficult. Related studies about the transportation problems of Panama, were not useful due to the time in which they were conducted. In the case of the information from the operators. The company Mi Bus, who is in charge of providing the transportation services, is presenting some legal problems, due to its poor service quality. Therefore, they were unable to provide information regarding: profit, operating cost, farebox recovery ratio, etc. This limited the evaluation of the subsidy schemes in a more quantitative direction.

Studies of transit subsidies: Another important limitation, was the lack of studies that apply AHP in the evaluation of the subsidy plans, this was a problem to set the criteria and the objectives. For future studies, is recommended to distribute the objectives divided into the four groups (Economic sustainability, social sustainability, environmental sustainability and financial sustainability) that were discussed in chapter 3. The main objective of this recommendation is the distribution of the criteria, so that the evaluation of the AHP could be

clear and the distribution of the weigh among each element would not be affected by objectives with just one measurement.

Survey design: For future works the design of the questionnaire should change and not be too long. This sometimes, respondents complain about the development of the comparison and in some cases seems difficult to answer.



# Bibliography

[1]Aaron Best, B. G., Huib van Essen, Arno Schroten, Udo Becker and Regine Gerike. Size, structure and distribution of transport subsidies in Europe. Denmark, European Environment Agency. 2007.

[2] Baker, S. and P. White. "Impacts of free concessionary travel: Case study of an English rural region." Transport Policy 17(1): 20-26. 2010.

[3] Bergstrom, F.. "Capital subsidies and the performance of firms. ." Small Business Economics 14(3): 183-193. 2000.

[4] Board, T. R. A guidebook for developing a transit performance-measurement system. Washington, D.C. 2003.

[5] Bruno De Borger, K. K.. The Performance of Bus-Transit Operators. Belgium University of Antwerp. 2006.

[6] Buehler, R. and J. Pucher. "Making public transport financially sustainable." Transport Policy 18(1): 126-138. 2011.

[7] Cees van Goeverden, P. R., Jorine Koelemeijer and Paul Peeters. "Subsidies in public transport " European Transport 32: 5-25. 2006.

[8] Cervero, R. "Flat versus Differentiated transit pricing: what´s a fair fare " Transportation 10: 211-232. 1981.

[9] Cervero, R. "Examing the performance impacts of transit operating subsidies " Urban transportation division. 1984.

[10] CIE. Subsidies and the social costs and benefits of public transportation Centre for International Economics. 2006.

[11] Clements, G. S. a. B. "Government Subsidies " Journal of Economic Surveys 13(2). 1999.

[12] Cruz, L., E. Barata and J.-P. Ferreira. "Performance in urban public transport systems: a critical analysis of the Portuguese case." International Journal of Productivity and Performance Management 61(7): 730-751. 2012.

[13] Drevs, F., D. K. Tscheulin, J. Lindenmeier and S. Renner. "Crowding-in or crowding out: An empirical analysis on the effect of subsidies on individual willingness-to-pay for

public transportation." Transportation Research Part A: Policy and Practice 59(0): 250-261. 2014.

[14] Echenique, A. G.-L. Affordability of public transport: A methodological clarification University of Chile. 2007.

[15] European Metropolitan Tranport Authorities. Study on electronic ticketing in public transport. 2008.

[16] Garrick, N. W., R. O'Hara, C. McCahill, C. Atkinson-Palombo and J. Zheng. "Quantifying the Economic Domain of Transportation Sustainability." Transportation Research Record: Journal of the Transportation Research Board 2242(-1): 19-28. 2011.

[17] Glauthier, G. J. F. a. R. E. Distribution and allocation of transit subsidies in California Transit management program University of California, Irvine. 1976.

[18] Gwilliam, K. "A review of issues in transit economics." Research in Transportation Economics 23(1): 4-22. 2008.

[19] Hidalgo, E. E. S. a. D. "TransMilenio: A high capacity-low cost bus rapid transit system developed for Bogota, Colombia ". 2003.

[20] Huang, S.-L., C.-T. Yeh, W. W. Budd and L.-L. Chen. "A Sensitivity Model (SM) approach to analyze urban development in Taiwan based on sustainability indicators." Environmental Impact Assessment Review 29(2): 116-125. 2009.

[21] Jackson, R. "Optimal Subsidies for Public Transit " Journal of transport Economics and Policy. 1975.

[22] Jennifer S. Shang, Y. T., and Yizhong Ding. "A unified framework for multicriteria evaluation of transportation projects. ."IEEE Transactions on Engineering Management. 51(3). 2004.

[23] Lan, L. W. Sustainable Development and Transportation: A Taiwan perspective National Chiao Tung University. 2005.

[24] Lan, L. W., M.-T. Wang and A. Y. Kuo. "Development and Deployment of Public Transport Policy and Planning in Taiwan." Transportation 33(2): 153-170. 2006.

[25] Laura Eboli, G. M. "Performance indicators for an objective measure of public transport service quality." Department of Land Use Planning, University of Calabria(51). 2012.

[26] Li, E. W. L. C. H. "Information priority-setting for better resource allocation using analytic hierarchy process (AHP)." Information Management & Computer Security 9(2): 61-70. 2001.

[27] Litman, T. "Sustainable Transportation Indicators " Transportation Research Board. 2008.

[28] Litman, T. "A Good Example of Bad Transportation Performance Evaluation." Victoria Transport Policy Institute. 2009.

[29] Litman, T. "Evaluating public transit benefits and Cost " Victoria Transport Policy Institute. 2013.

[30] Litman, T. "Understanding Transport Demands and Elasticity: How Prices and Other Factors Affect Travel Behavior." Victoria Transport Policy Institute. 2013.

[31] M. Berrittella, A. C., M. Enea and P. Zito. "An Analytic Hierarchy Process for The Evaluation of Transport Policies To Reduce Climate Change Impacts." Social Science Research Network Electronic Paper Collection. 2007.

[32] Marshment, R. S. Establishing Subsidy Levels for Rural Public Transportation Systems. Norman, Oklahoma University of Oklahoma. 1998.

[33] Matt G Karlaftis, P. M. "Operating Subsidies and Performance in Public Transit: An Empirical Study " Transportation Research Part A: Policy and Practice 32(5): 359-375. 1998.

[34] Mayeres, I.. "The Efficiency Effects of Transport Policies in the Presence of Externalities and Distortionary Taxes " Journal of transport Economics and Policy Vol 34, part 2: 233-260. 2000.

[35] McCarthy, M. G. K. a. P. S.. "Subsidy and public transit performance: A factor analytic approach " Transportation 24: 253-270. 1997.

[36] Metz, D.. "Transport policy for an ageing population." Transport Reviews 23(4): 375-386. 2003.

[37] Muñoz, J. C. and L. de Grange. "On the development of public transit in large cities." Research in Transportation Economics 29(1): 379-386. 2010.

[38] N. Estupinan, A. G.-L., R. Munoz-Raskin and T. Serebrisky. "Affordability and Subsidies in Public Urban Transport: What Do We Mean, What Can Be Done? ." Transport

[39] Reviews: A transnational Transdiciplinary Journal vol. 29(6 ). 2009.

[40] Nassi, C. D. and F. C. d. C. d. Costa. "Use of the analytic hierarchy process to evaluate transit fare system." Research in Transportation Economics 36(1): 50-62. 2012.
[41]Nijkamp, B. U. a. P.. "Unconventional funding of urban transport " Transportation Research part D vol. 7: 317-329. 2002.
[42] P A Pienaar, M. N. K. a. A. D. P.. "Public Transport: Lessons to be learnt from Curitiba and Bogota " Southern African transport Conference. 2005.
[43] Potter, M. E. a. A.. "Encouraging the commercial sector to help employees to change their travel behaviour." Transport Policy 10: 51-58. 2003.
[44] Pounds, F. V. W. a. S.. "Effects of Subsidies on Urban Public Transport " Transportation Vol 9 311-331. 1980.
[45] Pucher, J.. "Equity in Transit Finance: Distribution of Transit Subsidy Benefits and Costs Among Income Classes." Journal of the American Planning Association 47(4): 387-407.1981.
[46] Puentes, R.. Washington´s Metro: Deficits by Design Center on Urban and Metropolitan Policy and The Greater Washington Research Program. 2004.
[47] Robin Carruthers, M. D. a. A. S.. "Affordability of Public Transport in Developing Countries " Transport papers, The World Bank Group. 2005.
[48] Rye, T. and W. Mykura. "Concessionary bus fares for older people in Scotland – are they achieving their objectives?" Journal of Transport Geography 17(6): 451-456. 2009.
[49] Sadeghi, M. and A. Ameli. "An AHP decision making model for optimal allocation of energy subsidy among socio-economic subsectors in Iran." Energy Policy 45: 24-32. 2012.
[50] Santos, G., H. Behrendt and A. Teytelboym. "Part II: Policy instruments for sustainable road transport." Research in Transportation Economics 28(1): 46-91. 2010.
[51] Serebrisky, T., A. Gómez-Lobo, N. Estupiñán and R. Muñoz-Raskin. "Affordability and Subsidies in Public Urban Transport: What Do We Mean, What Can Be Done?" Transport Reviews 29(6): 715-739. 2009.
[52] Stein, E. W.. "A comprehensive multi-criteria model to rank electric energy production technologies." Renewable and Sustainable Energy Reviews 22: 640-654. 2013.
[53] Sun, Q., Q. Wang and B. Mao. "Framework Design of Different Transportation Modes' Energy Consumption Factors and Comparabilities Study." Journal of Transportation Systems Engineering and Information Technology 9(4): 10-14. 2009.

[54] Thomas L. Saaty, L. G. V.. Model, Methods, Conceptos and Applications of the Anlytic Hierarchy Process, International Series in Operations Research and Mangement Science 175. 2012.

[55] Tisato, P.. "Service Unreliability and bus subsidy " Transportation Research Part A: Policy and Practice Vol. 32(No. 6 ): 423-436. 1998.

[56] TRL. The demand for public transport: A practical guide Transport Research Laboratory Report. 593. 2004.

[57] Tscharaktschiew, S. and G. Hirte. "Should subsidies to urban passenger transport be increased? A spatial CGE analysis for a German metropolitan area." Transportation Research Part A: Policy and Practice 46(2): 285-309. 2012.

[58] Tuominen, A. and V. Himanen. "Assessing the interaction between transport policy targets and policy implementation—A Finnish case study." Transport Policy 14(5): 388-398. 2007.

[59] Turcksin, L., A. Bernardini and C. Macharis. "A combined AHP-PROMETHEE approach for selecting the most appropriate policy scenario to stimulate a clean vehicle fleet." Procedia - Social and Behavioral Sciences 20: 954-965. 2011

[60] The Wordl Bank. La Movilidad Urbana en el Área Metropolitana de Panamá. Elementos para una política integral. Departamento de Desarrollo Sostenible Región de Latinoamérica y El Caribe. 2007.

[61] Woldeamanuel, D. M. G.. "Evaluating the Competitiveness of Intercity Buses in Terms of Sustainability Indicators." Journal of Public Transportation Vol. 15,. 2012.

# Appendix 1

**Questionnaire**

**Evaluation of Transit Subsidy Plans Using Analytic Hierarchy Process: A case of Panama**

**Expert:**

The following survey questionnaire is directed to obtain your opinion as an expert to evaluate the relative importance of the criteria and the rankings of the alternatives.

**Personal Details (Optional)**

| | |
|---|---|
| **e-mail** | |
| **Organization:** | |
| **Occupation:** | |
| **Tel:** | |

## Evaluation of Sustainable Transit Subsidy Plans for Panama

The Organization for Economic Co-operation and Development defined subsidy as a result of a government action that confer an advantage on consumer or producers, in order to supplement their income or lower their cost. This economic aid is commonly used by many countries in develop and developing countries and Panama is not the exception. The reasons why subsidy is implemented can be enumerated as follows: Increase public transport use, reduce externalities (greenhouse gas emissions and congestion), provide an affordable transportation system and cover differences between passengers fare revenue and operating cost.

Subsidy to transportation in Panama is provided to maintain the low cost of public transport and to cover the operating cost. The present subsidy scheme of Panama needs to be evaluated, due to the new transportation projects developed by the government. Three different subsidy schemes are presented in this study with the objective of improving allocation efficiency, social distribution and promote the integration of the two systems (urban public bus and new metro line).

The propose methodology used in this research is the Analytic Hierarchy Process (AHP) a Multi-Criteria Decision method. The MCD Methods take into account multiple criteria and are an alternative solution in shaping and developing decisions and strategies. The AHP is developed using a hierarchy structure (Figure 1) in which the decision is decomposed into elements according to their common characteristics. The first level is the focus of the problem

"the Goal", the second level is the criteria and sub-criteria, which allows the decision maker to evaluate the different "decision alternatives". The elements of each level most be compared pairwise with respect to a specific element in the upper levels, to obtain the weights. The comparison is conducted using the Nine-point evaluation scale (Table 1) to convert the qualitative judgments of the experts into numerical values.

Table 1 Nine-Point Evaluation Scale

| Weight | interpretation |
|---|---|
| 1 | Equally preferred |
| 2 | Equally to moderately preferred |
| 3 | Moderately preferred |
| 4 | Moderately to strongly preferred |
| 5 | Strongly preferred |
| 6 | strongly to very strongly preferred |
| 7 | Very strongly preferred |
| 8 | Very to extremely strongly preferred |
| 9 | Extremely preferred |

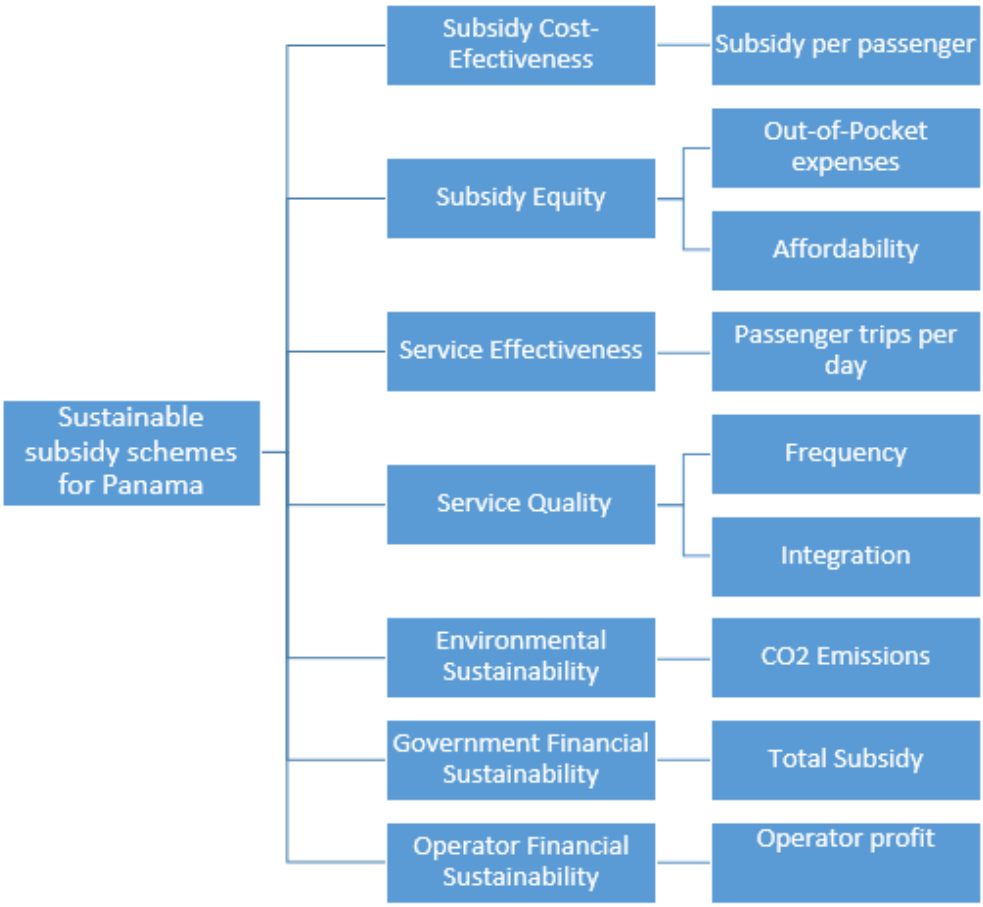



Figure 1: AHP Hierarchy Structure

The design of the subsidy schemes is based on the extensive literature review on the subject. A percentage of the subsidy budget used in 2013 was assigned to each type of subsidy proposed for the three schemes along with the proposed budget for the operations of the new metro line. The subsidy schemes are described as follows:

Table 2: Subsidy Schemes.

| **Subsidy Schemes** |
|---|
| **<u>Subsidy Scheme 1</u>**<br><br>5. 55% Fuel tax rebate for bus carriers.<br>6. 20% Flat fare scheme with a discount for students.<br>7. 15% operating subsidy to cover Metro operations.<br>8. 10% Fare subsidy. |

**Subsidy Scheme 2**

5. 20% Concessionary fare subsidy among students and elder, provided directly from government (implementing a fare discount for elder and disable).
6. 25% Capital subsidies to bus carriers for investment of fleet and provision of infrastructure.
7. 25% Capital subsidy to develop electronic ticketing system to integrate both systems and provide transfer discounts.
8. 30% operating subsidy for new metro line.

**Subsidy Scheme 3**

9. 30% Conditional operating subsidies based on performance for bus carriers.
10. 20% Flat fare subsidy with the discount for students.
11. 25% operating subsidy for metro line.
12. 25% Discount fare for transfers using bus and the metro system.

The evaluation of the different subsidy schemes will be performed in the three main routes of Panama City with more ridership; Via España, Transismica and Tumba Muerto. Relevant information about the routes is presented in Table 3 and Table 4.

Table 3: Routes Relevant Data.

| Route | Origen | Destination | Frequency | Daily Passengers | Length (Km) | Headway | Trips |
|---|---|---|---|---|---|---|---|
| **Via España** | Tocumen | Albrook | 7 | 2,315 | 35.28 | 9 | 36 |
| **Transistmica** | Tocumen | Albrook | 5 | 1,595 | 45 | 12 | 46 |
| **Tumba Muerto** | Mañanitas | Albrook | 8 | 2,630 | 30.5 | 7.5 | 32 |

Table 4: Criteria and Sub-Criteria

| Criteria | Description | Sub-criteria | Data |
|---|---|---|---|
| **Subsidy Cost Effectiveness** | The ability to meet the demand for transit services given existing resources. | **Subsidy per passenger** | Students: USD 0.15 |
| | | | Passengers: USD 0.24 |
| **Subsidy Equity** | Distribution of the cost and benefits of subsidies among income classes. A measure of equity, | **Out-of-pocket expenses** | Students: USD 0.10 |
| | | | Passengers: USD 0.25 |
| | | **Affordability** | High |

| | | | |
|---|---|---|---|
| | affordability which represents the portion of household expenditures devoted to transport. | | |
| **Service Quality** | Reflect the quality of service experienced by users | **Frequency** | See Table 3. |
| | | **Integration** | No-integrated |
| **Service Effectiveness** | Critical indicator of the success of a transit system. | **Passenger trips per day** | Via España: 83,340 |
| | | | Transisimica: 73,370 |
| | | | Tumba Muerto: 84,160 |
| **Environmental Sustainability** | Benefit of each modes of travel in terms of its contribution to environmental protection. Generally and depending on the occupancy rates public transport produces much lower CO2 emissions than private car. | **CO2 Emissions kg per passenger km** | Urban bus: 1.23 kg/per passenger km<br>Private car: 9.46 kg/per passenger km |
| **Governmental Financial Sustainability** | Appropriate distribution of state funds to achieve transit improvement. | **Total subsidy** | USD 200.5 million |
| **Operator Financial sustainability** | The amount of investment gained from produce unit system output. | **Total profit** | Profit=Farebox revenue + operating subsidy – operating cost |

**Survey**

**Evaluating Feasible Transit Subsidy Plans for Panama**

Based on personal opinion as an expert, compare the different elements with each other and provide a quantitative measure for the element of your preference using the Nine-point evaluation scale. **Remember that you can only choose one element and provide a quantitative value.**

1. Evaluate the relative importance of each Criteria with the given goal: **"Sustainable subsidy Plans for Panama"**. Rate the intensity of the importance of each CRITERIA using the scale and based on your opinion choose the element with the most relevant importance.

| **Scale** | **1= Equally preferred** | | | | | **3= Moderately** | | | **5= Strongly** | | | **7= Very Strongly** | | | **9= Extremely** | | | **2,4,6,8= Intermediate Values** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Cost Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Equity** |
| **Subsidy Cost Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Service Quality** |
| **Subsidy Cost Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Service Effectiveness** |
| **Subsidy Cost Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Environmental Sustainability** |
| **Subsidy Cost Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Governmental Financial Sustainability** |
| **Subsidy Cost Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Operator Financial Sustainability** |

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| **Subsidy Equity** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Service Quality** |
| **Subsidy Equity** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Service Effectiveness** |
| **Subsidy Equity** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Environmental Sustainability** |
| **Subsidy Equity** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Governmental Financial Sustainability** |
| **Subsidy Equity** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Operator Financial Sustainability** |
| **Service Quality** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Service Effectiveness** |
| **Service Quality** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Environmental Sustainability** |
| **Service Quality** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Governmental Financial Sustainability** |
| **Service Quality** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Operator Financial Sustainability** |
| **Service Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Environmental Sustainability** |
| **Service Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Governmental Financial Sustainability** |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Service Effectiveness** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Operator Financial Sustainability** |
| **Environmental Sustainability** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Governmental Financial Sustainability** |
| **Environmental Sustainability** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Operator Financial Sustainability** |
| **Governmental Financial Sustainability** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Operators Financial Sustainability** |

2. Evaluate the relative importance of each Sub-Criteria with the given Criteria: **"Subsidy Equity".** Rate the intensity of the importance of each SUB-CRITERIA using the scale and based on your opinion choose the element with the most relevant importance.

| **Scale** | **1= Equally preferred** | | | | | **3= Moderately** | | | **5= Strongly** | | | **7= Very Strongly** | | | **9= Extremely** | | | **2,4,6,8= Intermediate Values** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Out-of- Pocket Expenses** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Affordability** |

3. Evaluate the relative importance of each Sub-Criteria with the given Criteria: **"Service Quality".** Rate the intensity of the importance of each SUB-CRITERIA using the scale and based on your opinion choose the element with the most relevant importance.

| Scale | 1= Equally preferred | | | | | 3= Moderately | | | 5= Strongly | | | 7= Very Strongly | | | 9= Extremely | | | 2,4,6,8= Intermediate Values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Frequency** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Integration** |

4. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Subsidy per passenger".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| Scale | 1= Equally preferred | | | | | 3= Moderately | | | 5= Strongly | | | 7= Very Strongly | | | 9= Extremely | | | 2,4,6,8= Intermediate Values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

5. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Out-of-Pocket Expenses".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| Scale | 1= Equally preferred | | | | | 3= Moderately | | | 5= Strongly | | | 7= Very Strongly | | | 9= Extremely | | | 2,4,6,8= Intermediate Values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

6. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Affordability".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| Scale | 1= Equally preferred | | | | | 3= Moderately | | | 5= Strongly | | | 7= Very Strongly | | | 9= Extremely | | | 2,4,6,8= Intermediate Values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

7. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Passenger trips per day".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| **Scale** | **1= Equally preferred** | | | | | **3= Moderately** | | | **5= Strongly** | | | **7= Very Strongly** | | | **9= Extremely** | | | **2,4,6,8= Intermediate Values** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

8. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Frequency".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| **Scale** | **1= Equally preferred** | | | | | **3= Moderately** | | | **5= Strongly** | | | **7= Very Strongly** | | | **9= Extremely** | | | **2,4,6,8= Intermediate Values** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

9. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Integration".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| Scale | 1= Equally preferred | | | | | 3= Moderately | | | 5= Strongly | | | 7= Very Strongly | | | 9= Extremely | | | 2,4,6,8= Intermediate Values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

10. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"$CO_2$ Emissions".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| Scale | 1= Equally preferred | | | | | 3= Moderately | | | 5= Strongly | | | 7= Very Strongly | | | 9= Extremely | | | 2,4,6,8= Intermediate Values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

11. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Total Subsidy".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| **Scale** | **1= Equally preferred** | | | | | **3= Moderately** | | | **5= Strongly** | | | **7= Very Strongly** | | | **9= Extremely** | | | **2,4,6,8= Intermediate Values** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |

12. Evaluate the relative importance of each Alternative with the given Sub-Criteria: **"Total Profit".** Rate the intensity of the importance of each ALTERNATIVE using the scale and based on your opinion choose the element with the most relevant importance.

| **Scale** | **1= Equally preferred** | | | | | **3= Moderately** | | | **5= Strongly** | | | **7= Very Strongly** | | | **9= Extremely** | | | **2,4,6,8= Intermediate Values** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pairwise** | **Importance Scale** | | | | | | | | | | | | | | | | | **Pairwise** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 2** |
| **Subsidy Scheme 1** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |
| **Subsidy Scheme 2** | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Subsidy Scheme 3** |