METHODOLOGY FOR SELECTING CONCESSION HIGHWAYS IN THE BRAZILIAN STRATEGIC PLANNING CONTEXT

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1 – Introduction

In 1990, Brazilian government started a National Plan of Decentralization (PND) that involved all sectors of infrastructure. In transportation sector, Ministry of Transportation initiated its decentralization activities in 1993 in order to improve condition of existent highways based on Public Private Partnerships (PPP). Among PPP structures, concession has been employed based on time-term transference of recuperation and maintenance services in exchange for exploration rights such as payment of toll feel [1).

Since the beginning of the Brazilian Highways Concession Program (BHCP) in 1993, four federal highways and one bridge were transferred to private sector through concession model [2) 3)]. The selection of highways was based on investment cost, operational cost, revenue by toll fee, actual traffic volume, simulation of revenue, period of concession, etc, using the software HDM-III appraisal, which is developed by the World Bank [4)]. HDM-III is a popular approach used by highway agencies for evaluating and analyzing maintenance and rehabilitation options. The model combines technical and economic appraisal of highway projects, to prepare highway investment programmes and analyze highway network strategies. However, despite of worldwide application of HDM III [5) 6) 7)], it can be clearly verified that this tool was not developed for selecting concession highways as required in BHCP. Therefore, HDM is rather an evaluation tool for highway condition analysis than an instrument that can appraisal concession highways in a national planning context.

In order to overcome these limitations, this paper presents a methodology for selecting concession highways considering a strategic planning context. In this sense, the paper is divided into four sections. Firstly, theoretical assumptions are proposed in order to clarify the basis in which the methodology is conceived. Next, methodological phases are described aiming to obtain the priorities for selection of BHCP's highways. In the third section, the methodology is applied into a case study in Minas Gerais State, Brazil. Finally, the conclusion and recommendations topics are stated.

2 – Theoretical Assumptions

Towards the conception of the methodology for the selection of highways for BHCP, two main theoretical assumptions have to be established. First assumption is that, concession of highways, which means the improvement of highway conditions through a contract between public and private sectors, has to contribute for national development. The provision of adequate infrastructure and economic growth are highly interrelated. Infrastructure plays a critical role in promoting economic growth through enhancing productivity, improving competitiveness, reducing poverty, linking people and organizations together through telecommunications and contributing to environmental sustainability. Based on this, assume that improving infrastructure conditions tends to create a better environment that can support growing and appearance of activities. Consequently, employment and tax incomes are generated, which may contribute for improving quality of life.

The second main theoretical assumption is related to the necessity of providing circumstances that a concession highway be attractive to private investment. As BHCP is a PPP contract, which means that the interests of both involved actors (public and private sectors) have to be represented towards a Win-Win scheme, i.e., both sides have to reach equilibrium on their advantages and disadvantages through the concession of a highway, it is essential that private interests are also considered. In this sense, attractiveness to private investment can be represented through the consideration of operational characteristics of a highway.

Aiming to represent these main assumptions and based on analysis of criteria employed in highway project evaluations [8) 9) 10) 11)], a set of characteristics C can be defined for each highway i as shown in equation 1:

$$C_i = \{TV_i ; PC_i ; DG_i ; FR_i ; GDP_i\} \tag{1}$$

where,

TV- Traffic Volume represents the number of users on highway under analysis per kilometre;
PC- Physical Characteristics represents physical highways condition;
DG- Demography expresses demographical characteristics along the extension of the highway;
FH- Function of the Highway to express how the highway under analysis contributes for the system as a whole; and
GDP- Gross Domestic Product shows how active is the economy of a region / city.

Thus, based on the values of C for all highways under analysis, it is assumes that Multi-Criteria Analysis (MCA) can be applied for computing the priorities of each highway i (P_i), which express the necessity within the highway system to be

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transferred or not to a private sectors under a concession contract. Mathematically, it can be stated as shown in the equation 2:

$$P_i = f(C_i) \tag{2}$$

where f is a MCA function that establishes the weights between the characteristics C.

3 – Methodology for Selecting Highways in the BHCP using MCA

The methodological phases are described aiming to obtain the priorities for selection of BHCP's highways. These phases can be employed to develop concession scenarios that might be a basis for more detailed analysis such as HDM. In this sense, the methodology proposes the analysis of the highway system based upon MCA that provides a wide consideration of intervening factors. The application of this methodology can generate macro-strategic scenarios indicating those highways that should be deeply evaluated towards concession. The description of the methodology is divided into five phases in the sequence.

Phase I: Formation of the database

Required data comprehends information about the characteristics of the highway under analysis. As this methodology is devoted to strategic planning, a high level of details on highway characteristics is not fundamental to reach the priorities of each highway under analysis. In this sense, average daily traffic volume can express TV_i. PC_i can be represented by the pavement condition of the highway i. FH_i is obtained from the verification of what kind of connection is related to highway i. As DG_i and GDP_i are related to cities along and nearby the highway, they are, respectively, stated by summing the number of population and the pondered average of the GDP. Preferably, data of all highway characteristics has to be collected in the same period of the year in order to establish a common basis for analysis and it is essential to highlight that the origin of data may be from different sources but all of them being public agencies.

Phase II: Selection of Alternatives

The selection of alternatives contributes to reduce the range of possibilities to be analyzed. Then, considering highway network, this phase concentrates on the identification of a set of alternatives, which includes only paved highways and the highest level of highway jurisdiction. Additionally, in order to limit the amount of data required on cities along and nearby the highway under analysis, only cities with a minimum number of population need to be selected.

Phase III: Definition of impacts related to criteria (judgments)

As part of a MCA, this phase firstly intends to determine the relative weights between criteria (*TV*, *PC*, *DG*, *FH* and *GDP*). According to Bianco and Toth [12)], these weights reflect the relative importance of the criterion, which depends on the preferences of the decision makers.

Next, for each alternative A_j where $j \in \{1, 2, \ldots, j, \ldots, TNA\}$ and criterion c, where $c \in \{TV, PC, DG, FH, GDP\}$and TNA is Total Number of Alternatives. The criterion related impact e_{jc} has to be determined considering the database developed in the first methodological phase (phase 1). Computing each impact e_{jc} into a function f_c, which depends on the type of model employed in the MCA, a priority value u_{jc} interpreted as goal-achievement scores has to be obtained as shown in equation 3.

$$u_{jc} = f_c(e_{jc}) \tag{3}$$

where each function f_c provides a directly proportional transformation of impact e_{jc} into u_{jc}, specifically for this methodology.

Thus, towards obtainment of priority value u_{jc}, the impacts e_{jc} of each criterion c are defined according to the theoretical assumptions before as follows:

- *TV*: as a criterion that is devoted to generate minimum conditions for the participation of private capital from concessionaries, it is assumed that the highest *TV* identifies the highway that offers the most attractive highway in terms of revenue for private investment;
- *PC*: assuming that concession of the highway concerns a public property, it is essential to valorize actions that will improve the pavement condition. Then, it is assumed that if pavement condition is considered good, then concession of the highway under analysis is not urgent neither repair is required immediately. On the other side, highways in severe condition will need urgent repairs;
- *DG*: regions with high number of population show that they are already saturated. Oppositely, regions with reduced population call for investments to improve them. Therefore, they might be priorized when conducting the concession of the highway;
- *FH*: it is stated that highways linking capital cities are more important than the others, since they have fundamental importance on connecting areas that provide passing for industrial and agricultural products. On the other hand, highways linking small cities have minor importance, because their contribution for the system is reduced; and
- *GDP*: as it is essential to stimulate areas that present low values of *GDP*, it is expected that a concession highway might bring economical development for areas that lack of it. In the other side, cities, that already present high level of economical activities expressed by a high *GDP*, are not urgently suitable for additional improvements and investments.

Phase IV: Computing impacts (Priorization)

Considering the results of u_{jc}, a partial priority Z_{jc} has to be computed by applying equation 4, which express the relative importance of each alternative j and criterion c.

$$Z_{jc} = u_{jc} * W_c \tag{4}$$

Next, final alternative priority P_j is computed based on the equation 5 as follows.

$$P_j = \sum_c Z_{jc} \quad (5)$$

Phase V: Analysis of priorities

Based upon results from the application of equation 5, priorities of all alternatives under analysis (*TNA*) are obtained. These priorities show the potential of each alternative to be transferred to private companies through a concession program. More specifically, alternatives or group of alternatives with high priorities will be identified as strongly recommend to be transferred, since they combine characteristics *C* that will provide the development of the country and highway system as well. On the other hand, low P_j will indicate alternatives or group of alternatives that are mostly not suitable for transference under a concession program.

4 – Case Study

It was conducted in Minas Gerais (MG) state, which is the third biggest Brazilian state and occupies 586.552,38-Km^2. Population is around 17,8 million people, being 14,6 million living in urban area and 3,2 million living in rural area. Economically, MG has participation in 9,84% of national GDP. MG state's economy is mostly based on the production of minerals to supply metallurgy industries, which are located in South and Southeast regions of the state. On the other hand, agriculture activities are typically conducted in the North and Northeast regions. MG state has the longest highway system in Brazil.

However, paved highway system is not in a good condition, because of pavement age is high and periodical maintenance has not been frequently conducted. Aspiring to change this situation, federal administrative has been transferring highways to private companies. In this sense, the proposed methodology of the previous section is applied to generate information for decision-makers to select concession highways. Thus, this information will indicate the priority of each highway segment to be selected as a concession highway.

Firstly, it is important to choose the MCA method that will be used in the priorization analysis. We selected the Analytic Hierarchy Process (AHP) developed by Saaty [13)]. AHP is a popular decision-making tool for multi-criteria decision-making problems [14) 15)]. This technique is particularly interesting due to the establishment of a hierarchy for decision and quite simple participation of decision markers. It provides a method to assess goals and objectives by decomposing the problem into measurable pieces for evaluations using a hierarchical structure and comparative judgments.

AHP is based on human being behaviour to decide through the comparison between "objectives" until reaching a decision. The comparison is related to the assignment of "weights" according to the relative importance when comparing to pre-established judgment criteria. Using a quantitative scale all the "objectives" are compared leading to a prioritization and consequent decision. AHP has a simple structure that directly depends on the knowledge of the decision-marker, which is reached trough the obtainment of information about the problem. It contributes to choose the best or the most priority among alternatives. The output of AHP is a prioritized ranking indicating the overall preference of each of the alternatives.

The case study was conducted following the methodological phases as described in the section 3 and results are show in figure 1. Results show that there are distinct levels of priority for highway concession in MG State. For the sake of this analysis, we divided P_j values into five groups of priority. In a case-by-case analysis, it can be verified that:

- only the (I) and (II) priority groups are indicated as for future analysis and probable concession;
- results of group II is performance is due not only *TV*'s contribution criteria, but also the participation of the other criteria providing equilibrium for all cases of this group;
- third group, equilibrium among the criteria can be observed. We can conclude that these roads are related to regions already developed or saturated, which means that they do not need urgent resources in terms of road concession; and
- groups IV (low priority) and V (extremely low priority) do not gather sufficient conditions (economical attractiveness and developmental purposes) for conducting a concession program.

5 – Conclusion and Recommendations

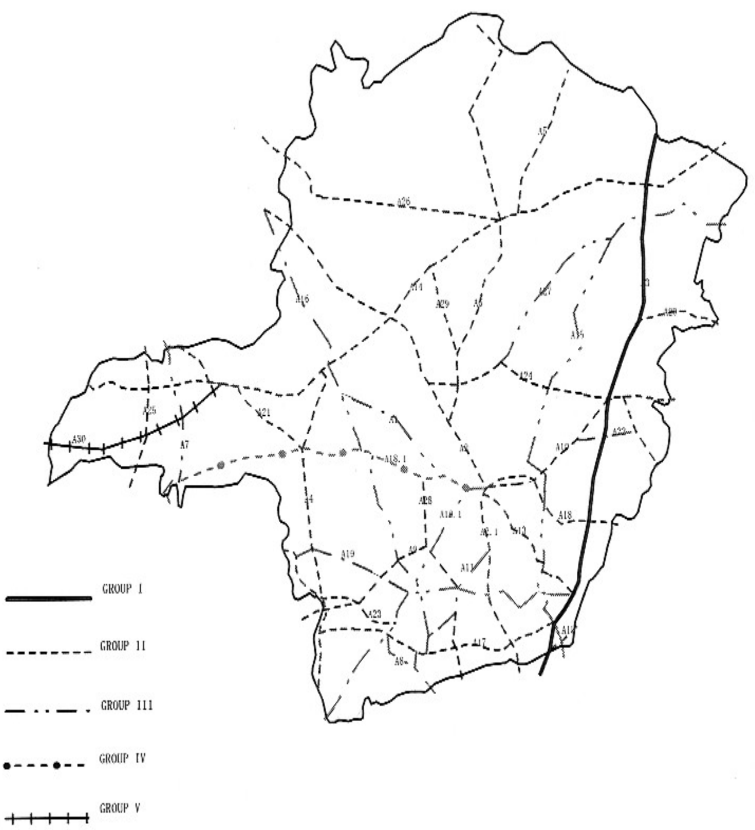
This research proposed a methodology in order to appraisal concession highways projects. In this sense, this paper tried to contribute to help decision-makers in the strategic level. The methodology is an instrument that provides information for macro appraisals based on MCA framework. The results from the application of the methodology, in the case study, show that it can be useful for decision making in MG state. Comparing with Minas Gerais Highway agency concession program analysis, our methodology provides a more efficient use of resources (data, personnel, time, money, equipments) and it generates outputs (priorities of concession highways) that are devoted to create future scenarios for national development.

The experience obtained in this research suggest some topics for future improvements and researches as following:

- Use of other methods for Road Project Evaluation, in order to explore different tools for the selection of concession highways;
- Incorporation into the proposed methodology of new criterion for expressing network influences on the selection of concession highways;
- Development of new methodologies based on the integration of Geographic Information Systems (GIS) and AHP in order to reach a better consideration of geo-spatial reality along the whole process of selection of concession highways;
- Conduct additional researches towards the study of techniques for choosing most suitable and skilled decision-makers for the selection of concession highways; and
- Creation of methodologies to identify lots of concession highways combining high and low priorities in order to simultaneously attract private financing and develops the nation.

Figure 1-Final results for all alternatives

Priority Group	*Aj*	Name	P_i(%)
I- Extremely High	3	BR-116	4.20
II- High	1	BR-352	3.95
	16	BR-354	3.87
	19	BR-265	3.68
	8	BR-460	3.59
	22	BR-458	3.57
	11	BR-383	3.50
	15	BR-120	3.42
	27	BR-367	3.36
	10.1	BR-381	3.28
III-Medium	6	BR-135	3.17
	14	BR-365	3.14
	2.1	BR-040	3.11
	23	BR-491	3.11
	28	BR-494	3.08
	26	BR-251	3.05
	17	BR-267	3.00
	7	BR-153	2.94
	25	BR-154	2.92
	21	BR-452	2.88
	29	BR-496	2.85
	24	BR-259	2.82
	12	BR-393	2.75
	4	BR-146	2.74
	9	BR-369	2.73
	5	BR-122	2.68
	2	BR-040	2.67
	10	BR-381	2.67
	18	BR-262	2.67
	13	BR-356	2.66
	20	BR-418	2.62
IV- Low	18.1	BR-262	2.10
V- Extremely Low	30	BR-497	1.23



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