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## Road and Rail Infrastructure IV

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## APPLICATION OF SENSITIVITY ANALYSIS FOR INVESTMENT DECISION IN BUILDING OF UNDERGROUND GARAGE

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### Abstract

Sensitivity analysis is frequently used for investment decision in connection with the assessment of investment project in uncertainty conditions. The paper contains key parameters defined by application of sensitivity analysis in a model of discounted cash flow of project of underground garages. The analysis was done by varying individual input parameters from the minimum to the maximum assumed default value. The parameters identified as critical are those on whose change the profitability of the project showed to be particularly sensitive. Also, the paper contains individual effect of each critical parameter to the net present value of the investment over project time of 20 years. The analysis was done for four scenarios of garages of different capacities. The paper could be used in preliminary reviews and preparation of studies on options to resolve problems of parking demand in urban parts of cities.

*Keywords: sensitivity analysis, parking, underground garage, profitability*

### 1 Introduction

A parking space became the problem of almost all bigger urban areas. High-raisers and condensed content of other activities frequently require more parking spaces. It is a fact that a passenger car remains still over 90% of time. Therefore, securing standstill (car parking) conditions becomes starting condition for traffic system operation.

Increase of motorisation level caused greater demand for parking spaces. Lacking it more and more are being taken surfaces not intended for parking. As a consequence, it is not rare case that car owners use street parking in streets where it is not legally allowed.

Having this in mind, there is no doubt that parking present huge urban problem the solution of which implies a well thought out approach both in socio-economic and technical aspect.

As space needed for standstill traffic greatly exceeds objective possibilities – i.e. city areas are already very busy due to other necessary contents – the construction of underground garages is seen as a possibility for partial solution of this problem.

Nevertheless, it is usually very difficult to ensure finances for construction of these garages in local communities' budgets. Therefore, a Public Private Partnership (PPP) Model is seen as a possible solution for financing the construction of such infrastructure objects. In other words, the contract stipulates obligations under a form of the PPP for a defined (contracted) period of time.

In order to be interested in investing a private partner must have financial return on investment within the project period. However, public garages are not being constructed for profit or financial gain, but because of chronic shortage of parking space in urban areas of the city. Financial analysis show that such investments return only in approximately ten years. The sole source of private partner income in this case is parking space payment. At the same time, according to parking policy, the local community's priority is to address the needs of

the residential customers. That is why the percentage of parking spaces for these customers has to be imposed as an obligation for the private partner. This per cent, however, greatly impacts the project profitability.

After the financial feasibility and sustainability is verified by the Discounted Cash Flow Model, it is necessary to define risks that are vital in making investment decisions. Namely, in calculation of Net Present Value (NPV) all parameters (i.e. cash flows, discount rate, interest rate and other) contain specific level of risk in assessment. Consequently, the NPV is a risk data itself.

## 2 Sensitivity analysis and definition of key parameters

The sensitivity analysis is a technique used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. This procedure is often used in investment decision-making related to investment project evaluation under conditions of uncertainty. By applying this analysis it is possible to find the maximum or minimum points of a value while the investment project is still justified and acceptable for realization.

A set of criteria used in the investment project evaluation comprise of: Net Present Value (NPV), Internal Rate of Return (IRR), Pay-Back Period (t), Benefit-Cost Ratio (B/C) etc. The input values on the basis of which it is possible to calculate specific individual criteria are: income, costs, value of investment, discount rate, interest rate, etc. (Figure 1).

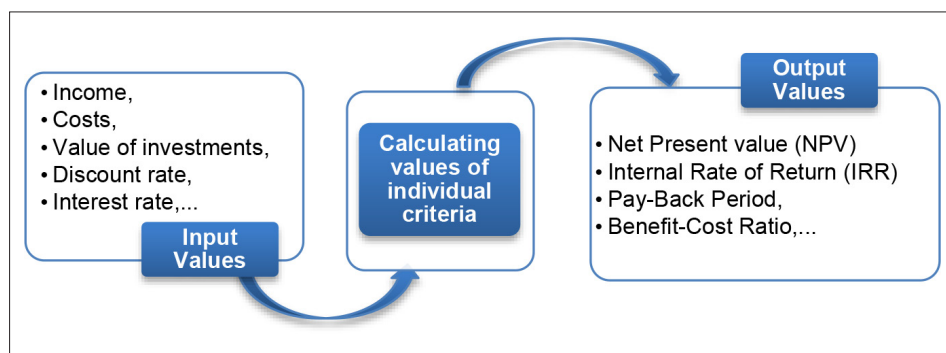


Figure 1 Calculation of individual criteria using input and output values

Analysis of cash flow was done under assumption of Public Private Partnership (PPP) option of financing of underground garage construction with equal number of underground and over-ground parking spaces (approximately 25 m<sup>2</sup> surface). Taking into account the fact that construction of multiple underground floors significantly increases the construction costs, analysis was based on construction of only one underground floor.

The analysis further was based in case a private partner finances the project from its own sources and with credit funds from commercial banks in 30:70 per cent ratios. The credit has been calculated for 10 years including two years of grace period with accrual of interest on the principal part. The interest rate was 6.369%, while the calculation included credit application fees of 1.5%. The contractual period was 20 years.

The building and maintenance prices are recent ones in Bosnia and Herzegovina and presented in the following Tables 1 and 2 in EUR/parking space (PS). Four scenarios related to capacity and garage surface have been also analysed (Table 3).

**Table 1** Investment costs

No.	Costs	Value (EUR/PS)
1.	Design and review of technical documentation	348
2.	Licences (electric, water, fallout shelter, etc.)	1,495
3.	Building	10,737
4.	Building supervision	138
5.	Compensation for Building Rights	949
	<b>TOTAL</b>	<b>13,666</b>

**Table 2** Operating costs

No.	Costs	Value (EUR/PS)
1.	Salaries	205.00
2.	Utility services costs	46.00
3.	Maintenance costs	31.00
	<b>TOTAL</b>	<b>282.00</b>

**Table 3** Analysed scenarios

Scenario	Number of parking spaces (underground + over-ground)	Footprint [m <sup>2</sup> ]
Garage 1	50+50=100 PS	1,250
Garage 2	100+100=200 PS	2,500
Garage 3	150+150=300 PS	3,750
Garage 4	200+200=400 PS	5,000

The sensitivity analysis is particularly useful in determining areas where risk is difficult to identify. The basic idea behind the analysis is keep all variables fixed in the Discounted Cash Flow Model except one and then to test the sensitivity of the Net Present Value (NPV) or the Internal Return Rate (IRR) against changes of tested value. Basic settings in analysis were the following:

- Occupancy = 70%;
- Parking price for residential customers = EUR 35 per month;
- Parking price for other customers = EUR 0.50;
- Share of residential customers = 50%;
- Discount rate = 12%.

The criteria used to determine critical parameters were the following:

- Value is deemed critical if the change thereof for 1% resulted with change of over 5% of the Financial (FNPV) or the Economic Net Present Value (ENPV).
- Value is deemed of critical importance if the change thereof for 1% resulted with change of over 1% of the Financial (FIRR) or the Economic Internal Rate of Return (EIRR).

Sensitivity analysis was applied to following parameters:

- 1) Demand (occupancy),
- 2) Parking price,
- 3) Share of residential customers,
- 4) Building costs,
- 5) Interest rate, and
- 6) Discount rate.



The results of the sensitive analysis are given in Table 4.

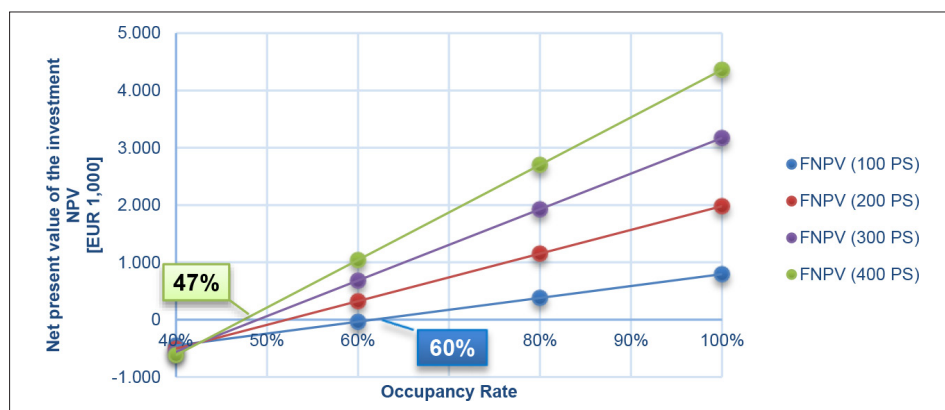
**Table 4** Sensitivity analysis

No.	Costs	Value of FNPV change [%]	Value of FIRR change [%]
1.	Demand (occupancy)	3.20	1.34
2.	Parking price	3.20	1.36
3.	Share of residential customers	2.84	1.21
4.	Investment costs	2.11	1.26
5.	Interest rate	0.33	0.18
6.	Discount rate	2.16	0.014

It is visible in the above table that parameters: demand, parking price, share of residential customers and building costs make critical ones based on Financial Internal Rate of Return (FIRR) criteria as their change for 1% resulted with FIRR change for more than 1%. Hereinafter each of these criteria shall be discussed individually and analysed their impact to project feasibility, i.e. Net Present Value of the investment over 20 year period for defined scenarios (Table 3).

### 2.1 Impact of demand (occupancy) of garage

It is desirable that occupancy of parking is the greatest possible. However, due to daily even weekly nonlinearity, an average occupancy can vary in quite big intervals. The paper examined the impact of occupancy to FNPV when it varies from 40 to 100% while all other values remain fixed. The following Figure 2 has presented comparative chart for all four scenarios.



**Figure 2** Relation between Occupancy Rate and NPV (source: Author)

It can be seen in the above graph that the smallest garage of total 100 PS (50 underground + 50 over-ground) has a limiting occupancy value of min 47%. That means that below this value garage of this size is no longer financially cost effective in the given exploitation period. As size and capacity of the garage increase so does the limiting occupancy value. In case of Garage 4 with total 400 PS (200 underground + 200 over-ground) this limit moves to min 60%. Hence, it can be generally concluded that with increase of the garage capacity grows the per cent of needed occupancy so as to ensure its financial cost effectiveness.



## 2.2 Impact of parking price

The analysis of parking prices encompasses prices ranging from 0.3 to 0.6 EUR/h. The following Figure 3 contains chart showing change of FNPV with change of parking price for all four scenarios. It can be seen that limiting cost effectiveness is lower for garages of greater capacities. That way, for garage of total 400 PS it is 0.34 EUR/h. However, with decrease of garage capacity the limiting cost effectiveness increases and for garage of 100 PS it is 0.45 EUR/h. Hence, the risk of parking price change is far greater in case of smaller capacities garage than the bigger ones. That means that in case of bigger garages, with insufficient occupancy, there is space to reduce parking price without risk to have the investment non-cost effective. In case of smaller garages this value is pretty fixed and leaves no particular space for greater parking price reduction.

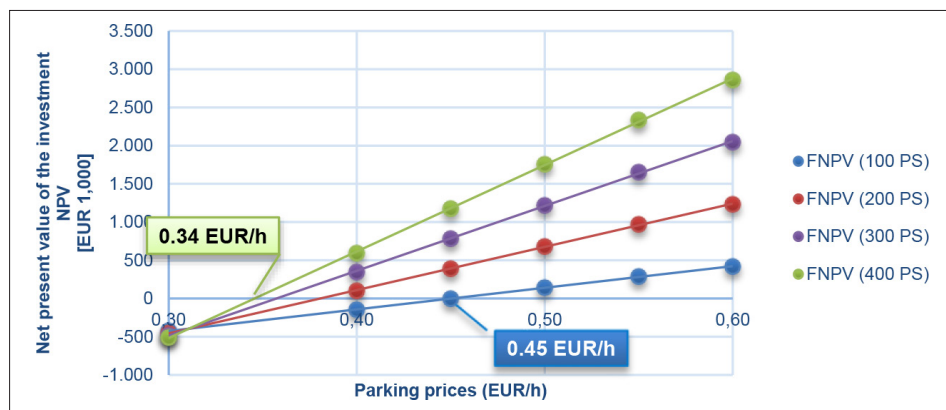


Figure 3 Relation between parking price and NPV (source: Author)

## 2.3 Impact of share of residential customers

Since this percentage is defined by the parking policy, the sensitivity analysis has been applied for change of per cent share of residential customers from 0 to 100%. The following Figure 4 presents all four scenarios.

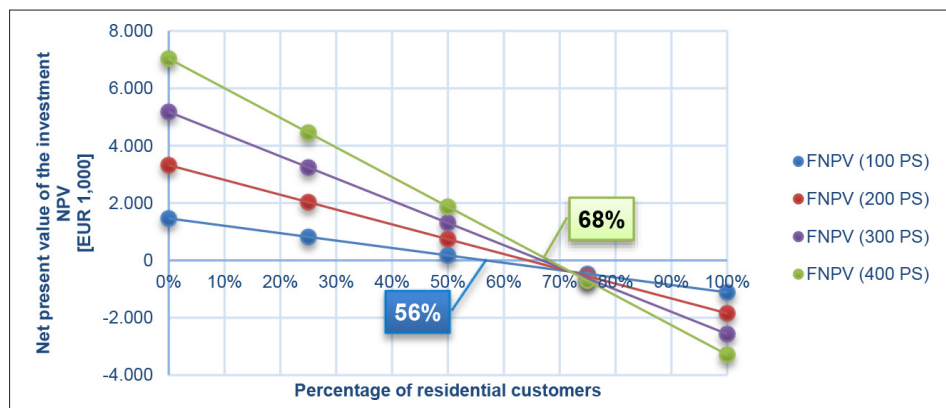


Figure 4 Relation between residential customers and NPV (source: Author)

For very small underground garages the percentage of residential customers would be maximum 56%, constituting the limit of financial cost effectiveness. It is, however, visible that this limit also increase with increase of the garage capacity and for Scenario 4 the point of cost effectiveness is at 68%. In theory, the graph indicates that this value cannot be above 72% for some maximum garage capacity.

## 2.4 Impact of building costs

The sensitivity analysis showed that building cost also present one of the critical parameters. In the Figure 5 it can be seen that with increase of the parking space capacity the FNPV declines more rapidly and building price representing limiting cost effectiveness value for the smallest garage about 485 EUR/m<sup>2</sup>, while in case of bigger garage this value is about 610 EUR/m<sup>2</sup>.

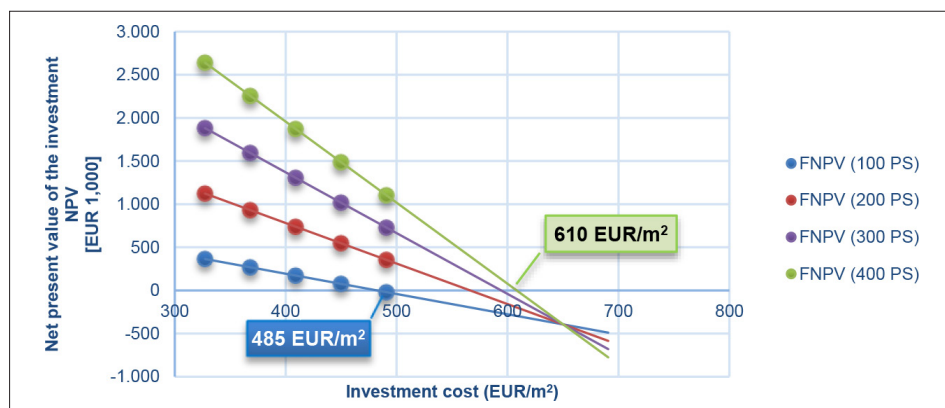


Figure 5 Relation between investment cost and NPV (source: Author)

## 3 Conclusion

In this paper it has been performed the sensitivity analysis of impact parameters to financial cost effectiveness of the project of construction and long-term use (20 years) of underground garage. The analysis has been carried out for four scenarios. Namely, garages of different capacities with one underground floor and one over-ground parking surface have been compared. The sensitivity analysis showed that the critical parameters are:

- 1) Demand (occupancy) of the parking space,
- 2) Parking price,
- 3) Share of residential customers, and
- 4) Building costs.

For each of the listed parameters, sensitivity test has been done, while all four scenarios were shown in parallel. Parameters of demand and parking price have ascending character, i.e. as they increase so does the Financial Net Present Value (FNPV). Two remaining parameters relating to per cent share of residential customers and building costs have descending character. As they increase the FNPV of the investment decline. From afore analysis and comparison the limiting values of these parameters where FNPV=0 have been derived. The following Table 5 contains comparison results for garages with the smallest and the biggest capacities.

**Table 5** Comparative results

No. Costs	FNPV=0	
	Garage 1 (50 + 50 PS)	Garage 4 (200 + 200 PS)
1. Demand (occupancy)	min 60 [%]	min 47 [%]
2. Parking price	min 0,45 [EUR/h]	min 0,34 [EUR/h]
3. Share of residential customers	max 56 [%]	max 68 [%]
4. Investment cost	max 485 [EUR/m <sup>2</sup> ]	max 610 [EUR/m <sup>2</sup> ]

Hence, the occupancy of parking space for garages of total 100 parking spaces should not be less than 60%. For garages four times bigger the minimum occupancy is about 47%.

Derives values can be useful in preliminary analysis in case of investment decision for construction of underground garage. Still, assumptions based on which the analysis has been carried out including recent prices in Bosnia and Herzegovina should be taken into account. By applying the sensitivity analysis, information can be gathered on effects of input parameters onto tested criteria for estimation of investment project aimed at investment decision making. The sensitivity analysis can also enable decision maker to adequately overview the problems.

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