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On the evaluation of urban logistics intermodal terminal projects

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Abstract

This paper is looking to incorporate uncertainty and risk in the financial assessment of an urban logistics investment project – a ““rail-road” intermodal terminal performing urban logistic distribution functions. A “cost benefit analysis” (CBA) is performed for four decision scenarios (with different destinations and technologies). The variables included in the CBA are treated as random variables with different distribution functions (uniform, binomial, normal). The net present value (NPV) used to rank the different decision scenarios is based on results from a Monte Carlo simulation. NPV obtained as a discrete variable has been used to evaluate risk (expressed with specific indicators) and for the comparison with a NPV of a similar project in operation. A comparison with CBA that expresses NPV deterministically and the “states of nature” with known probabilities is made. Under uncertainty conditions (the “states of nature” completely unknown) the preferences of the decision maker are analysed for a certain scenario depending on his/her attitude towards risk (cautious, optimistic, pessimistic). The CBA is complemented by a “cost-efficacy analysis” (CEA) which reflects the manner in which the non-financial, social consequences of the project can be used to rank the decision scenarios. In conclusion, the paper pleads for the professionalism required by CBA and CEA, when risk and uncertainty cannot be ignored, this being the case of most infrastructure investments with social implications difficult to estimate financially.

Keywords: Investment; evaluation; cost benefit/efficacy/utility analysis; net present value; risk; uncertainty

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1. Introduction

Similar to any other investment project, the urban logistics projects (infrastructure, handling, transportation, e-systems) need technical, financial and economical feasibility studies. Technical feasibility takes into consideration the efficiency of the different type of engineering and logistical solutions (purchasing, distribution, internal, reverse) or of integrated logistics (supply chain). Financial feasibility studies need to convince investors that they will recuperate their investment and make a certain profit. Economical feasibility adds to the financial consequences the impact on customers, residents, society, usually without monetary value, therefore not of interest to the private investor.

Generally no major difficulties are encountered when it comes to the ranking of various technical solutions, but in the case of financial and more so economical assessment of the investment projects, controversies continue and stimulate debate between experts of different backgrounds (engineers, economist, sociologists, ecologists, lawyers).

Although the two types of analysis (financial and economical) are based on different evaluations, they do have common elements. They both use the classical cost-benefit analysis (CBA). Even when the financial flows are determined, the calculation of the net present value (NPV) for a certain project is controversial. The controversies relate to the value of the discount rate (r) used in calculations and the length of the time period (T) over which the financial flows are summed ([1],[2], [3], [4]).

If we take into account the fact that the hypothesis of deterministic financial flows over long periods of time the NPV is calculated can rarely be sustained, then to the above mentioned controversies (relating to r and T) have to add the uncertainties relating to the size of the financial flows taken into account for project evaluation.

The uncertainties regarding the size of the financial flows, even in the case of a predictable and stable financial market, are generated by the randomness of the demand and supply over relatively large time horizons.

The way in which the randomness is included in the CBA depends on the preferences of the decision makers. The manner in which financial flow uncertainties are derived from the classical consumer theory, using the utility function ([3], [5]) is less appropriate when it comes to assessing the uncertainty in project evaluation ([6], [7], [8], [2], [9]). Hence, this paper looks at the public decision maker interested in the present value of the financial flows for each project in relation to each “state of nature”. In this case the attitude of the decision makers towards uncertainty is modelled through the result of the present value calculation. This is different to the classical method mentioned before, which is based on present utilities estimations corresponding to the aggregated uncertainties of the different periods.

Few clarifications in relation to the “random” attribute ([1], [10], [11]) used for the size of the financial flows:

- when probabilities can be associated to the random variations of the financial flows, so the financial flows can be described as a random variable (discrete or continuous), the NPV estimation is performed under “risk” conditions;
- when probabilities cannot be associated to the random variations of the financial flows, so the “states of nature” are unknown even probabilistically, the NPV estimation is performed under “uncertainty” conditions.

2. Investment project evaluation under conditions of “risk” and “uncertainty”

2.1. Nature of the investment

The intention is to financially assess the investment opportunity into a rail-road intermodal terminal ([7], [12], [13], [14]) that will distribute to the hypermarkets located in outer Bucharest. There have been identified four mutually excluding design options. In two of them the terminal performs cross-docking activities (for general freight, respectively for temperature controlled freight, scenarios I and II), and in the other two, the terminal performs distribution centre with stock functions (for general freight, respectively for temperature controlled freight, scenarios III and IV).

As for the case of other transport infrastructure projects several sources of randomness have been indentified; their consequences are reflected in the scenario evaluation. Some of these sources of randomness are as follows: demand (size, structure, temporal characteristics) for the terminal, operational costs (means of transport, loading/unloading/handling, energy, wages, local/global negative external effect), the competitive and regulatory context, duration, economical and financial variables, concession risks, juridical clauses, human resources for the management, completion and operation of the project ([15], [16], [17], [3]).

The consequences of the randomness introduces by sources of the nature mentioned above in the NPV estimation for each decision scenario are summarised in Table 1.

Table 1. Decision scenario characteristics (* values in 10 mil. Euro)

Characteristics \ Decision scenario		Cross-docking		Urban distribution centre (with stock)	
		General freight I	Temperature controlled freight II	General freight III	Temperature controlled freight IV
Competitive market - probability of satisfying conditions to reach objective		0.60	0.40	0.60	0.40
Probability of satisfying conditions for cross-docking		0.70	0.70	0.30	0.30
Initial investment*		0.8	0.95	1.2	1.5
Operation expenses	distribution	normal	normal	normal	normal
	mean/standard deviation*	0.5; 0.1	0.5; 0.1	0.4; 0.06	0.4; 0.06
Revenue	distribution	normal	normal	normal	normal
	mean/standard deviation*	0.6; 0.1	0.75; 0.12	0.65; 0.08	0.7; 0.08
Storage revenue	distribution	---	---	normal	normal
	mean/standard deviation*			0.15; 0.03	0.25; 0.05
Subsidies	distribution	binomial	binomial	binomial	binomial
	mean*	0.1	0.08	0.05	0.1
	probability of awarding	0.3	0.3	0.3	0.3
Residual value	distribution	uniform	uniform	uniform	uniform
	mean*	0.15	0.20	0.18	0.25
	interval [a; b]	[0.10; 0.20]	[0.18; 0.22]	[0.12; 0.24]	[0.20; 0.30]

Annual operation investments and costs are assumed to be deterministically expressed.

2.2. Evaluation under "risk" conditions

For the conditions in Table 1, the decision preferences are ranked depending on the net present value (NPV) of each scenario.

If the financial flows S are deterministic, then NPV, corresponding to the discount rate r and time period T is:

$$NPV(S,r)=\sum_{t=0}^{T}\frac{S_t}{(1+r)^t}+\frac{R_T}{(1+r)^T} \quad (1)$$

where S_t is the financial flow of year t,
R_T – residual value from year T of the investment made at t = 0.

Respectively, for random financial flows, if the discount rate r exogenous, hence constant, NPV is:

$$\mathrm{E}[NPV(S,r)]=\sum_{t=0}^{T}\frac{\mathrm{E}(S_t)}{(1+r)^t}+\frac{\mathrm{E}(R_T)}{(1+r)^T} \quad (2)$$

where $\mathbb{E}$ ( ) are the mean values of the variables in brackets.

Besides the mean value for the synthetic characteristic of the random variable *NPV(S, r)* the value of the variance is also useful:

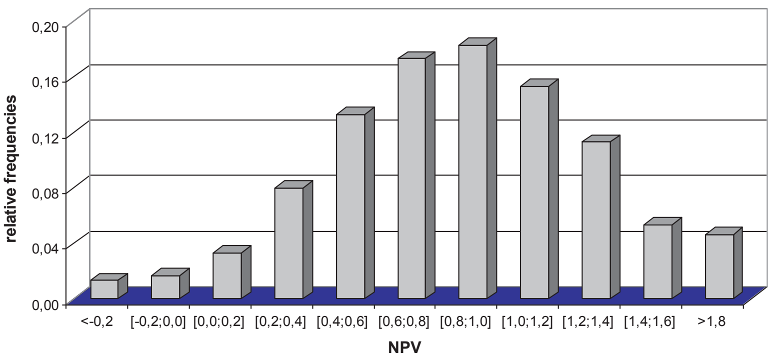
$$Var[NPV(S,r)]=\sum_{t=0}^{T}\frac{Var(S_t)}{(1+r)^{2t}}+\frac{Var(R_T)}{(1+r)^{2T}}+2\sum_{t\neq t'}\frac{Cov(S_t,S_{t'})}{(1+r)^{t+t'}}+2\sum_{t=0}^{T}\frac{Cov(S_t,R_T)}{(1+r)^{t+T}} \quad (3)$$

where $Cov(S_t, S_{t'})$ is the covariance of S_t and $S_{t'}$.

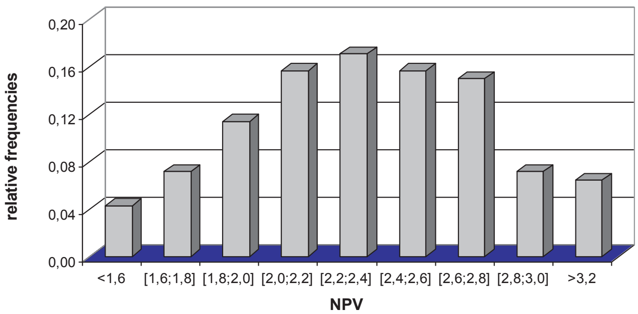
The calculation of mean and dispersion with *(2)* and *(3)* allows a first approximation of the stochastic elements in Table 1, which are then used to calculate *NPV* for the proposed decision scenarios.

The intention to offer a more complete characterisation of the effect of the random variables in Table 1 onto NPV, lead to the use of Monte Carlo simulation ([18], [19]). An uniform random number generator has been used to obtain the values of the elements according to the distributions indicated in Table 1 (binomial, uniform, normal), values required for the calculation (1) of the 1000 values of *NPV* for $T = 10$ *years* and $r = 0.06$, respectively of other 1000 values of *NPV* for $T = 20$ and same value of the discount rate. As a result of the simulation for each of the four decision scenario the probability density functions have been obtained (Fig. 1).

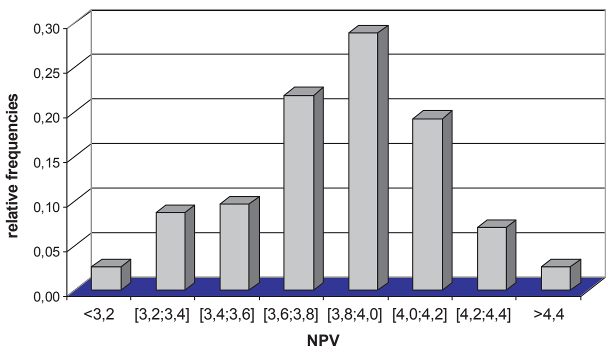
In relation to the manner in which through Monte Carlo simulation the values of NPV have been deducted in order to obtain the probability density functions, the following explanations are provided.



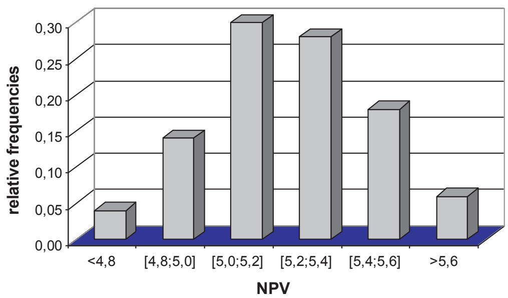
a) scenario I "cross-docking, general freight" (300 values, $E(NPV_I) = 0.85; Var(NPV_I) = 0.19$);



b) scenario II "cross-docking, temperature controlled freight" (140 values; $E(NPV_{II}) = 2.32; Var(NPV_{II}) = 0.18$);



c) scenario III "UDC, general freight" (115 values; $E(NPV_{III}) =3.83; Var(NPV_{III}) = 0.09$)



d) scenario IV "UDC, temperature controlled freight" (50 values; $E(NPV_{IV}) =5.25; Var(NPV_{IV}) = 0.06$)

Fig. 1. Probability density functions for *NPV (T = 20 years; r = 0.06)*

The random number transformation *Ni*, uniformly distributed on (0, 1) into values with a certain distribution law has been done as follows:

1. For the binomial distribution with probability *p* of occurrence of the favourable event the value of *Ni* has been compared with the given value *p*; if *Ni* was less or equal to *p*, then it has been considered that the favourable event occurs, respectively the decision scenario of probability *p*; otherwise the calculation for the complementary case has been performed;
2. For the uniform distribution on [a, b], the value *xi* of the random variable *X* has been obtained as follows:

$$x_i = a + (b - a)N_i \tag{4}$$

3. For the normal distribution with the mean value $\overline{X}$ and the standard deviation σ_x, the current value x_i in each run of the simulation has been obtained as follows:

$$x_i = 2\sigma_x \sqrt{\frac{3}{n}} \left(2\sum_{i=1}^{n} N_i - n \right) + \overline{X} \tag{5}$$

where *n* is the number of random numbers used to obtain a value x_i of the random variable with normal distribution (considered n = 6).

The histograms corresponding to *NPV* for *T = 10 years* and *T = 20 years* (Fig. 1), as well as the *E(NPV)* and *Var(NPV)* values allow the ranking of the decision scenarios (scenarios are ordered from highest to lowest, IV, III, II, I, for both *T = 10 years*, and *T = 20 years)*.

The relatively low values of dispersion, and the relatively high difference between the means of *NPV* for different decision scenarios suggest the possibility of obtaining same hierarchy even if the calculation of *NPV* would have been based on mean values of the components in equation (1), and the probabilities of occurrence of each scenario would have not been taken into account.

The results of the calculations (Table 2) in the above mentioned hypothesis, for *T = 10 years*, illustrates the same hierarchy of the four decision scenarios. The mean of *NPV* calculated with the values in Table 2 is 1.56, almost equal to the value obtained from the simulation (1.55).

Table 2. Values of NPV (T = 10 years; r = 0.06) in the four decision scenarios and occurrence probabilities

Decision scenarios *i* / Characteristics	Cross-docking		Urban distribution centre (with stock)	
	General freight I	Temperature controlled freight II	General freight III	Temperature controlled freight IV
NPV_i	0.75	1.59	2.21	3.33
Probabilities of occurrence, p_i	0.42	0.28	0.18	0.12

The “expected shortfall”, calculated relative to a reference value, $NPV_0 = 1.3$ of an existent similar investment:

$$R = \sum_{i=1}^{4} p_i \max\{NPV_0 - NPV_i, 0\} = 0.23 \tag{6}$$

meaning a difference of 0.23 million euro from the existing similar investment.

The efficacy rate of the project is:

$$R_{ef} = \frac{\sum_{i=1}^{4} p_i \max\{\mathrm{E}(NPV_0) - NPV_i, 0\}}{\sum_{i=1}^{4} p_i \max\{NPV_i - \mathrm{E}(NPV_0), 0\}} = 0.47 \tag{7}$$

meaning, relative to the existing investment, the project generates an average efficiency superior to the losses.

The financial feasibility of the project can also be outlined by introducing some measures of risk, such as “the value of risk” *(VaR)* and “the conditional value at risk” *(CVaR)*:

1. The *value at risk (VaR)* corresponding to the minimum risk of *NPV* if a set of unfavourable events with low probability of occurrence is discarded; this means that *VaR* for project A in scenario ξ, for *NPV* $J_A(\xi)$, $VaR_{J_A(\xi)}(p)$, is the greatest quantity *q* which with a probability less or equal to *p* makes *NPV* inferior to *q*:

$$VaR_{J_A(\xi)}(p) = \max\left\{ q \;\middle|\; \mathrm{P}\{J_A(\xi) \le q\} \le p \right\} \tag{8}$$

where $J_A(\xi)$ is a random variable (*NPV* of the project) and $VaR_{J_A(\xi)}(p)$ for the trust level *p* (considered $p = 0.05$ and $p = 0.01$).

The value at risk *(VaR)* for a project allows the expression through a single number of the synthetic characteristic of the project in relation to risk. *VaR* depends on:

- the *NPV* distribution of the project throughout the whole calculation period;
- the trust level, *p*;
- the time period desired for measuring *VaR*.

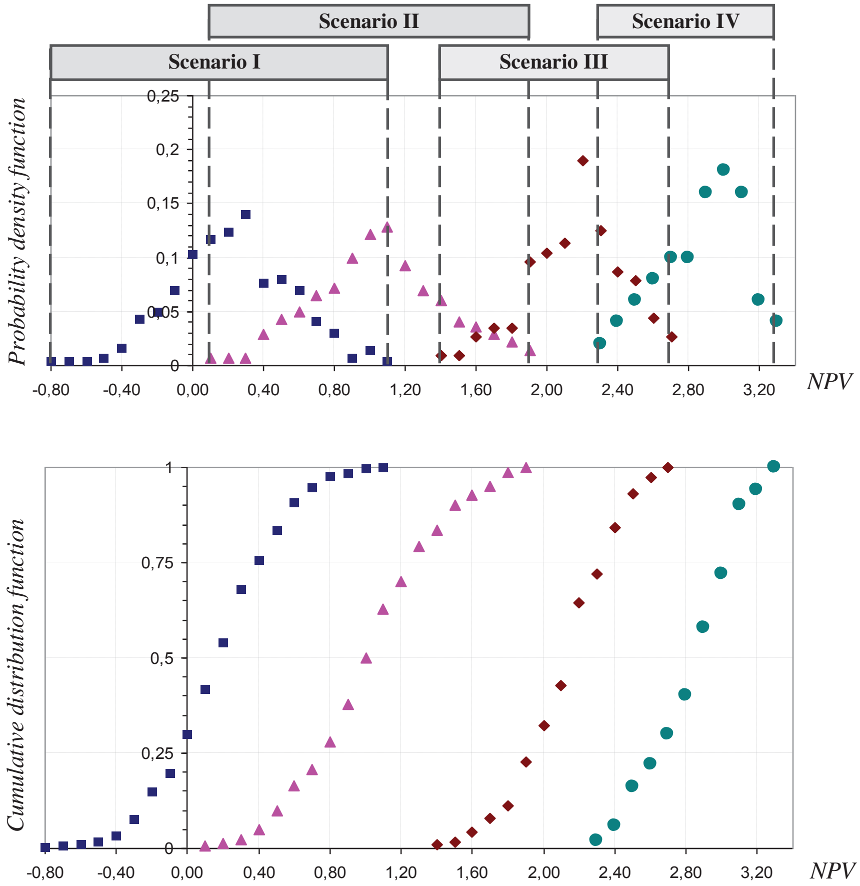
2. The conditional value at risk *(CVaR)* corresponding to *NPV* for project A calculated as an average for the most unfavourable cases:

$$CVaR_{J_A(\xi)}(p) = \mathrm{E}\left[J_A(\xi) \;\middle|\; J_A(\xi) \le VaR_{J_A(\xi)}(p) \right] \tag{9}$$

The conditional value at risk (CVaR) is characteristic of the tail of the random variable distribution. It also allows the evaluation of the mean value of the random variable (especially *NPV*) for the most unfavourable scenarios. The *CVaR* calculation is interesting in practice because it refers to a measure of an extreme risk (not the case of *VaR,* which does not offer a measure of the losses if the unfavourable event occurs).

There are several methods ([1],[2]) which allow the calculation of *VaR*: historical analysis, variance-covariance method, and Monte Carlo simulation. Besides avoiding the reproduction of some statistics, a historical analysis could not been performed in order to evaluate *VaR* due to lack of data.

The variance-covariance method assumes that both the efficiency of the project and the risk factors are normally distributed. Even though this hypothesis is not empirically justified it allows a huge simplification of the calculations. The main disadvantage of the method though is that rare events are underestimated.



Legend

- **Scenario I** "cross-docking, general freight" (300 iterations, $E(NPV_I) = 0.22; StDev(NPV_I) = 0.326$)
- **Scenario II** „cross-docking, temperature controlled freight (140 iterations; $E(NPV_{II}) = 1.05; StDev(NPV_{II}) = 0.374$)
- **Scenario III** „UDC, general freight" (115 iterations; $E(NPV_{III}) = 2.20; StDev(NPV_{III}) = 0.26$)
- **Scenario IV** „UDC, temperature controlled freight" (*50* iterations*;* $E(NPV_{IV}) = 2.87; StDev(NPV_{IV}) = 0.24$)

Fig. 2. Empirical functions of the probability density and distribution of *NPV*, from Monte Carlo simulation for $T = 10$ *years* and $r = 0.06$

Monte Carlo simulation is the most rigorous method but requires extensive calculations. For the VaR and CVaR calculations in the four project scenarios the distributions of NPV from the Monte Carlo simulation have been used, with the mean and dispersions as shown in Fig. 2. To simplify the calculations the assumption of NPV values corresponding to a normal distribution has been made, and results are shown in Table 3.

Regardless of the p values, the values of *VaR* and *CVaR* show the same decision preference order in relation to the four studied scenarios (IV, III, II, I, from the highest to the lowest preference). In the case of scenario IV, for example the *CVaR* values show that with a minimum probability of 0.95 a mean value of *NPV* greater than 2.33 is obtained, respectively with a minimum probability of 0.9, a mean *NPV* value greater than 2.16 (the mean value of *NPV* being 2.87). At the same time, for the same scenario the *VaR* values show that the *NPV* values are superior to the 2.48 value with a probability of 0.95, respectively superior to the 2.56 value with a probability of 0.9.

Table 3. Values of VaR and CVaR for the four decision scenarios (calculation horizon T = 10 years)

Risk measures / Decision scenarios i	$p = 0.05$		$p = 0.1$	
	VaR	*CVaR*	*VaR*	*CVaR*
Scenario I	- 0.3	- 0.55	- 0.19	- 0.51
Scenario II	0.43	0.21	0.57	0.31
Scenario III	1.64	1.48	1.74	1.56
Scenario IV	2.48	2.33	2.56	2.16

Taking into account the *NPV* values from Table 2, and calculating the utility of each decision scenario, results $\max_i p_i \cdot NPV_i = 0.42$, corresponding to scenario II (followed by scenario III and IV with quasi equal utilities, and scenario I last), meaning a different hierarchy of the preferences from the previous results (the results of the Monte Carlo simulation with the mean *NPV* values, and also the values obtained for *VaR* and *CVaR*).

2.3. Evaluation under "uncertainty" conditions

In a cost benefit analysis (CBA) where risk evaluation is a more complex problem, when it is impossible to compile a complete list of the possible future events and moreover cannot estimate the probability of occurrence of future events, analysts treat the problem as "game against nature".

Hereafter, the assumption of a certain state being the result of a random and non strategic selection of nature is made. This means that the actions (strategies) of the decision maker cannot affect the states of nature.

In these conditions, "states of nature" need to be identified, the actions (strategies) of the decision maker, and the consequences of these actions for each state of nature need to be established. If for each state of nature the elements involved in the CBA can be calculated deterministically, then selecting the strategy only depends on the attitude of the decision maker. This can be anywhere between maximum caution and the optimism of the person after maximum return, oblivious to risks. Accordingly, different decision rules are used: "cautious" rule (or the "minimax" criterion of Neumann-Wald), "optimistic" rule (or the "maximax" criterion), "pessimistic-optimistic" rule (or Hurwicz criterion), Bernoulli-Laplace rule (or the principle of insufficient evidence), minimum regret rule (or Savage criterion) ([6], [1]).

Follow the application of minimum regret rule where the decision maker chooses the scenario in which in case of occurrence of the most unfavourable state of nature will regret the least the respective decision:

$$\min_i \max_j (a_{ij}),\quad i=\overline{1,m},\quad j=\overline{1,n} \tag{10}$$

$$a_{ij} = \max_i (u_{ij}) - u_{ij} \tag{11}$$

where u_{ij} is the utility of the strategy *i* in the case of *j* state of nature.

For the analysed project, the *NPV* values for the three states of nature ξ_1, ξ_2 and ξ_3 are shown in Table 4. The regret matrix is obtained, the a_{ij} values in Table 5.

Table 4. Values of NPV for the project in the three states of nature

States of nature / Decision scenarios	ξ_1	ξ_2	ξ_3
Scenario I	0.75	0.80	0.65
Scenario II	1.59	1.35	2.15
Scenario III	2.21	3.48	2.98
Scenario IV	3.33	2.10	2.55

Table 5. Regret matrix associated to the project

States of nature / Decision scenarios	ξ_1	ξ_2	ξ_3	Maximum regret
Scenario I	2.58	2.68	2.33	2.68
Scenario II	1.74	2.13	0.40	2.13
Scenario III	1.12	0	0	1.12
Scenario IV	0	1.30	0.43	1.30

The minimum regret corresponds to scenario III, hence this is the recommended scenario (according to this rule).

By applying the other rules different decision preferences will result. This means that if the uncertainty of the states of nature (socio-economical environment) is great (cannot be evaluated probabilistically) a subjective attitude of the decision maker will prevail in selecting the investment strategy. In relation to this situation the analysis can be complemented with examinations of the “cost-efficacy” or “cost-utility” correlations.

2.4. “Cost-efficacy” and “cost-utility” evaluation

When CBA is difficult to use ([16], [1], [3]) in order to rank the decision scenarios, projects can be evaluated with the aid of the “cost-efficacy analysis” (CEA) or “cost-utility analysis” (CUA). The cases in which CEA or CUA are good alternatives to CBA or complement it, can be summarised as follows:

1. when the consequences of the project cannot be expressed financially;
2. when not all the consequences of the project can be quantified with CBA;
3. when the results of the project are interim goods.

In the case of the analysed project, if consequences like better supply of the hypermarkets and preserving the quality of the goods, or the contribution of warehousing towards reducing urban congestion are considered, then motivations such as the ones presented above can be found to complement the CBA with CEA and/or CUA.

In both CEA and CUA the scenarios are compared relative to the relation between the total cost of the project and a single non-financial result of the project. For efficacy for example, the volume of "reduced equivalent vehicle km" or "reduced tonnes of CO" for each scenario can be selected. This way the social efficacy (local and global) of the project can be determined.

The cost efficacy ratio (*CE*) can be calculated for each scenario *i*, $CE_i = C_i / E_i$, perceived as an average cost over the efficacy unit, or the efficacy cost ratio (*EC*), $EC_i = E_i / C_i$. Both relations involve the calculation of a ratio between consumption and results (or the other way round) for each project scenario. For two decision scenarios V_i and V_j can calculate a "cost- efficacy increase ratio":

$$\Delta CE_{i-j} = \frac{C_i - C_j}{E_i - E_j} \tag{12}$$

which, when *Vi* is more expensive and has better efficacy than *Vj* can be interpreted as the average cost increase for a supplementary unit of efficacy.

The use of CEA implies few delicate issues. Firstly, it is preferred to include in the scenario cost all social costs. But, in order to simplify the analysis, identical costs in all scenarios can be omitted without changing the scenarios' order in CEA (the ΔCE ratios change if they are calculated in relation to an existing situation and not between the new scenarios).

Secondly, CEA takes into account a single value of efficacy, even though normally, the effects of projects are multiple (CBA includes all financial ones). Thus, in the case of costs to the budget, in order to include other positive effects of the project the "*adjusted* $\overleftrightarrow{CE}$ " is calculated (as the ratio between the difference in social costs and the measure selected for the efficacy of the project).

Thirdly, applying CEA as a decision rule supposes most of the time a minimum level of efficacy $\underline{E}$ or a maximum acceptable cost $\overline{C}$. In the first case, the scenario with $\min_i CE_i$, for $E_i \geq \underline{E}$ would be selected, and in the second case the scenario with $\max_i EC_i$, for $C_i \leq \overline{C}$.

In Table 6, for the decision scenarios of the analysed project the ranking has been performed with CEA. In an initial evaluation the costs of subsidies (considered as social costs) from Table 1 have been used, and then the sum of the investment costs (multiplied by $r = 0.06$ in order to be assimilated as annual costs) and subsidies costs, the efficacy E_i of each scenario has been considered through reductions in traffic (relative to scenario I, evaluated as ΔT). A different hierarchy of the decision scenarios results from CEA as opposed to CBA (under risk and uncertainty conditions).

Table 6. Ranking the decision scenarios with CEA

Decision scenarios	E_i Efficacy (reduced traffic)	C_i Subsidies	CE_i C_i / E_i	Rank	C_i' Investments and subsidies	$C'E_i$ C_i' / E_i	Rank
Scenario I	ΔT	0.1	0.1/ΔT	2°	0.15	0.15/ΔT	2°
Scenario II	0.5ΔT	0.08	0.16/ΔT	4°	0.14	0.3/ΔT	4°
Scenario III	1.2ΔT	0.05	0.04/ΔT	1°	0.13	0.13/ΔT	1°
Scenario IV	0.7ΔT	0.1	0.14/ΔT	3°	0.19	0.27/ΔT	3°

The CUA analysis is similar to CEA with the only observation that there are delicate problems ([1], [20]) in relation to the definition of social utilities for an investment project which impacts on the quality of life.

3. Conclusions

The investment projects in the technical infrastructure of urban logistics require besides technical evaluations also financial and economical evaluations (based on global social costs). The use of CBA in financial evaluations to rank decision scenarios in relation to the technically feasible options of a project, supposes the inclusion of randomness of the variables used in calculation. The long periods of time CBA's take to be completed exclude deterministic approaches. The randomness involved in the financial/economical evaluation of an investment is expressed through the discount rate (influenced by macro-economical uncertainty) and the evaluation of benefits. High discount rates (around 8%) to compensate for the uncertainty of CBA calculations have not proven productive. The difference between the risks associated with the various solutions does not become apparent. Medium discount rates (4-6%) have been incorporated in more advanced sensitivity studies. The randomness of the variables included in the evaluation cannot be replaced by a sensitivity analysis in relation to the successive variations of one of the variables. Their complementary variations have to be taken into account. Monte Carlo simulation, regardless of the extensive calculations is the recommended method.

To evaluate the sensitivity of the *NPV* (*NPV* treated as a random discrete or continuous variable) to the risk factors for each decision scenario, the use of "the value at risk", "the conditional value at risk", "the expected shortfall" and "the efficacy rate" of the project is recommended. This way a hierarchy of decisions is made, based both on the complementary randomness of the variables in calculation, and the risk associated with a certain choice.

Under uncertainty conditions ranking the decision scenarios is highly subjective. The preference for using the "minimum regret" criterion that reflects the most balanced attitude of the decision maker is not effective in eliminating the uncertainty in selection relative to the "states of nature", totally unknown to the decision maker.

The CBA analysis, especially in the cases mentioned in the paper is recommended to be complemented by CEA or CUA. The manner in which CEA or CUA leads to rankings in agreement with CBA depends on the costs value, and the way in which the non-financial estimation of "efficacy" or "utility" is performed. These are all delicate problems that need clarifications.

All types of analysis used in the project (CBA, CEA), and also CUA are affected by randomness, which over long periods of time is difficult to estimate even probabilistically. Hence, major investment projects require complex evaluations, using multiple analysis tools, and as accurate as possible evaluations of the impact of risk and uncertainty onto the recommended decision scenario for the project.

The evaluation of urban logistics infrastructure investments should take into consideration the social utility of the project. The likely impacts of completing such an infrastructure project has to raise the interest of stakeholders and individuals with social or investment resources in order to participate in the urban and land use strategic decision process.

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