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Selection decisions based on the scenario of cash flows

Evaluación de criterios de decisiones basado en formato de flujo de caja: Enfoque de escenario

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Content

ABSTRACT:
The situation of selecting the best decisions for generating cash flows in the context of the three canonical scenarios (pessimistic, the most probable, optimistic) is considered. The authors demonstrate that traditional criterion evaluations lead to paradoxical selection results that do not meet the principle of rationality and can be attributed to a surrogate cluster of dominance. Criteria of optimality in the format of scenario cash flows, suggested by the authors, allow to form their objective cluster; selection of decisions is presented as a multi-objective task under conditions of risk and uncertainty; to show analysts and practicing top managers of various business types other windows of opportunity.
Keywords: Scenarios, criteria of optimality, paradoxes of choice, manipulation, surrogate and objective valuation models

RESUMEN:
Se considera la situación de seleccionar las mejores decisiones para generar flujos de efectivo en el contexto de los tres escenarios canónicos (pesimista, más probable, optimista). Los autores demuestran que las evaluaciones de criterios tradicionales conducen a resultados de selección paradójicos que no cumplen con el principio de racionalidad y que pueden atribuirse a un grupo sustituto de dominancia. Los criterios de optimalidad en el formato de los flujos de efectivo de los escenarios, sugeridos por los autores, permiten formar su grupo objetivo; la selección de decisiones se presenta como una tarea multiobjetivo en condiciones de riesgo e incertidumbre; para mostrar a los analistas y a los altos ejecutivos de diversos tipos de negocios otras ventanas de oportunidad.
Palabras clave: Escenarios, criterios de optimalidad, paradojas de elección, manipulación, modelos de valoración sustituta y objetiva

"First of all, we need facts,
and then they can be misinterpreted"
(Mark Twain)

1. Introduction

Top managers have an opportunity to select an effective financial solution (asset, option, etc.) from some set that satisfies the accepted system of objective-subjective constraints.

The forecast period is quantized into a kind of time segments for which, for each financial solution, the possible values of cash flows are determined for at least three scenarios - pessimistic, the most probable, and optimistic. It is required for this scenario format to offer top-managers such optimality criteria, in the context of which the chosen dominant financial solution can be considered effective (the best, rational). In a variety of calculations related to the selection of effective solutions (projects, leasing, financial assets trading, schemes for issuing and repaying loans, options for mergers and acquisitions, etc.) on the basis of maximized cash flows (CFS – Cash Flows Stream) in a scenario format, usually analysts use the following data:

$t = \overline{1,T}$ – periods of time under consideration;

$x_i \in X = (x_i, i = \overline{1;n})$ – options for financial decisions;

$S_j \in S = (s_j, j = \overline{1;m})$ – scenarios for events development (as minimum three (m=3): pessimistic, the most probable , optimistic);

$CF_{tij} \in CF$ – cash flows (CF → max) in period $t = \overline{1,T}$ for selecting decision $x_i \in X$ and realization of scenario $S_j \in S$. Here and further it is taken into consideration that CF=(CIF – COF) = Cash Inflow – Cash Outflow).

Selection of the best decision $x_{i_0} \in X$ assumes the formation of a "decisive rule" –the criterion of optimality

$$F(x_{i_0}) = \underset{x_i \in X}{\text{extr}}\, F(x_i). \tag{1}$$

1.2. Traditional Criterial Models

Among the numerous analysts, the following schemes for the formation of criterial valuation models are the most popular.

Scheme 1

$$F_1(x_{i_0}) = \min_{x_i \in X} \sum_{t=1}^{T} \Delta CF_{ti}^{max}; \tag{2}$$

$$F_2(x_{i_0}) = \max_{x_i \in X} \sum_{t=1}^{T} \Delta CF_{ti}^{min}. \tag{3}$$

Concept: the closer CF_{ti2} to CF_{ti1} and farther to CF_{ti3}, the less preferred is the decision $x_i \in X$. Formally, it looks like that.

$$\text{If } \Delta CF_{ti}^{max} \begin{cases} \leq \Delta CF_{ti}^{min}, \text{then for } x_i \in X \text{ in perriod t the risk} \\ \quad \text{of getting minimal cash flows is lower;} \\ > \Delta CF_{ti}^{min}, \text{then for } x_i \in X \text{ in period t the risk} \\ \quad \text{of getting minimal cash flows is higher.} \end{cases}$$

Let's consider this scheme using authors' fictional-conditional, elegant and methodically verified example (Table 1,2).

Table 1

Scenario Cash Flows (t=1)

x_i	CF \ S_j	S_1	S_2	S_3
x_1	$CF(t, x_1 \in X, s_j \in S) = CF_{tij}$	15	35	50
	$\Delta CF_{t1}^{max} = (CF_{t13} - CF_{t12})$	-	15=(50-35)	
	$\Delta CF_{t1}^{min} = (CF_{t12} - CF_{t11})$	12=(15-3)		-
x_2	$CF(t, x_2 \in X, s_j \in S) = CF_{tij}$	3	15	25
	$\Delta CF_{t2}^{max} = (CF_{t23} - CF_{t22})$	-	10=(25-15)	
	$\Delta CF_{t2}^{min} = (CF_{t22} - CF_{t21})$	12=(15-3)		-

Table 2
Scenario Cash Flows (t=T=2)

x_i	CF \ S_j	S_1	S_2	S_3
x_1	$CF(t, x_1 \in X, s_j \in S) = CF_{tij}$	10	20	40
	$\Delta CF_{t1}^{max} = (CF_{t13} - CF_{t12})$	-	20=(40-20)	
	$\Delta CF_{t1}^{min} = (CF_{t12} - CF_{t11})$	10=(20-10)		-
x_2	$CF(t, x_2 \in X, s_j \in S) = CF_{tij}$	55	70	80
	$\Delta CF_{t2}^{max} = (CF_{t23} - CF_{t22})$	-	10=(80-70)	
	$\Delta CF_{t2}^{min} = (CF_{t22} - CF_{t21})$	15=(70-55)		-

As a result we get:

$$F_1(x_{io}) = F_1(\boldsymbol{x_2}) = min\begin{cases} F_1(x_1) = (15+20) = 35; \\ F_1(x_2) = (10+10) = \mathbf{20}. \end{cases}$$

$$F_2(x_{io}) = F_2(\boldsymbol{x_1}) = max\begin{cases} F_2(x_1) = (20+10) = \mathbf{30}; \\ F_2(x_2) = (12+15) = 27. \end{cases}$$

We would like to present a few natural comments .

1. For the period of time t=1 $CF(x_1)$ dominates over $CF(x_2)$ in all selected scenarios ($CF(x_1, t=1) \succ CF(x_2, t=1)$).
2. For the period of time t=T=2 the situation is opposite: ($CF(x_2, t=2) \succ CF(x_1, t=2)$). In other words, $CF(x_1)$ и $CF(x_2)$ are in compromise, forming Pareto multiplicity [1].
3. If we disregard the phenomenon of discounting (assume that the discount rate is zero), then the additive criterion can be expressed in the form of a simple arithmetic mean:

$$F(x_{i_0}) = \max_{x_i \in X} \sum_{t=1}^{T} (\frac{1}{m} \sum_{j=1}^{m} CF_{tij}); \tag{4}$$

$$F(\boldsymbol{x_2}) = max\begin{cases} F(x_1) = \frac{1}{3}(15+35+50) + \frac{1}{3}(10+20+40) = 56{,}67; \\ F(x_2) = \frac{1}{3}(3+15+25) + \frac{1}{3}(55+70+80) = \mathbf{82,66}. \end{cases}$$

Conclusion: ($\boldsymbol{x_2} \succ \boldsymbol{x_1}$).

4. But, if we introduce value ($V_i, i = \overline{1,n}$) of cash flow unit for $t = \overline{1,T} = 2$: $v_1 = 0{,}8; v_2 = 0{,}3$, then we will get:

$$F(x_{i_0}) = \max_{x_i \in X} \sum_{t=1}^{T} V_t (\frac{1}{m} \sum_{j=1}^{m} CF_{tij}); \tag{5}$$

$$F(\boldsymbol{x_1}) = max\begin{cases} F(x_1) = 0{,}8\frac{100}{3} + 0{,}3\frac{70}{3} = \mathbf{33,67}; \\ F(x_2) = 0{,}8\frac{43}{3} + 0{,}3\frac{205}{3} = 31{,}97. \end{cases}$$

Conclusion: ($\boldsymbol{x_1} \succ \boldsymbol{x_2}$), but if we assume that $v_2 = 0{,}5$, then we will get again that ($\boldsymbol{x_2} \succ \boldsymbol{x_1}$).

Scheme 2

Let's also consider the following (rather surrogate) model criteria evaluations of selection $x_{i_0} \in X$.

$$F_3(x_{i0}) = \min_{x_i \in X} \sum_{t=1}^{T} \left(\frac{\Delta CF_{ti}^{max}}{CF_{ti2}} \right); F_4(x_{i0}) = \min_{x_i \in X} \sum_{t=1}^{T} \left(\frac{\Delta CF_{ti}^{max}}{CF_{ti3}} \right); \quad (6)$$

$$F_5(x_{i0}) = \max_{x_i \in X} \sum_{t=1}^{T} \left(\frac{\Delta CF_{ti}^{min}}{CF_{ti1}} \right); F_6(x_{i0}) = \max_{x_i \in X} \sum_{t=1}^{T} \left(\frac{\Delta CF_{ti}^{min}}{CF_{ti2}} \right); \quad (7)$$

$$F_7(x_{i0}) = \min_{x_i \in X} \sum_{t=1}^{T} \left(\frac{F_3(x_i)}{F_6(x_i)} \right); F_8(x_{i0}) = \min_{x_i \in X} \sum_{t=1}^{T} \left(\frac{F_4(x_i)}{F_5(x_i)} \right). \quad (8)$$

In these models, the following formalized concept is realized:

$$If \left(\frac{\Delta CF_{ti}^{max}}{CF_{ti2}} \right) \begin{cases} \geq \left(\frac{\Delta CF_{ti}^{min}}{CF_{ti2}} \right), \text{then for } x_i \in X \text{ risk for period } t \text{ increases;} \\ < \left(\frac{\Delta CF_{ti}^{min}}{CF_{ti2}} \right), \text{then for } x_i \in X \text{ risk for period } t \text{ decreases.} \end{cases}$$

$$If \left(\frac{\Delta CF_{ti}^{max}}{CF_{ti3}} \right) \begin{cases} \geq \left(\frac{\Delta CF_{ti}^{min}}{CF_{ti1}} \right), \text{then for } x_i \in X \text{ risk for period } t \text{ increases;} \\ < \left(\frac{\Delta CF_{ti}^{min}}{CF_{ti1}} \right), \text{then for } x_i \in X \text{ risk for period } t \text{ decreases.} \end{cases}$$

Illustrative example of calculations is presented in Table 3.

Table 3
Selection of the Best Decisions

CF \ $x_i \in X$	x_1	x_2	Comments
$CF_{t1}(x_i)$	15	3	
$CF_{t2}(x_i)$	35	15	$x_1 \succ x_2$
$CF_{t3}(x_3)$	50	35	
$\Delta CF_t^{max}(x_i) \to \min\limits_{x_i \in X}$	15=(50-35)	20=(35-15)	
$\Delta CF_t^{min}(x_i) \to \max\limits_{x_i \in X}$	20=(35-15)	12=(15-3)	–
	15<20→risk decreases	20>12→risk increases	
$F_3(x_i) = \left(\frac{\Delta CF_t^{max}(x_i)}{CF_{t2}(x_i)}\right) \to \min\limits_{x_i \in X}$	$\mathbf{\frac{15}{35} = \frac{3}{7}}$	$\frac{20}{15} = \frac{4}{3}$	$x_{i0} = x_1$
$F_4(x_i) = \left(\frac{\Delta CF_t^{max}(x_i)}{CF_{t3}(x_i)}\right) \to \min\limits_{x_i \in X}$	$\mathbf{\frac{15}{50} = 0{,}3}$	$\frac{20}{35} = \frac{4}{7}$	$x_{i0} = x_1$
$F_5(x_i) = \left(\frac{\Delta CF_t^{min}(x_i)}{CF_{t1}(x_i)}\right) \to \max\limits_{x_i \in X}$	$\frac{20}{15} = \frac{4}{3} = 1{,}33$	$\mathbf{\frac{12}{3} = 4}$	$x_{i0} = x_2$
$F_6(x_i) = \left(\frac{\Delta CF_t^{min}(x_i)}{CF_{t2}(x_i)}\right) \to \max\limits_{x_i \in X}$	$\frac{20}{35} = \frac{4}{7}$	$\mathbf{\frac{12}{15} = \frac{4}{5} = 0{,}8}$	$x_{i0} = x_2$
$F_7(x_i) = \left(\frac{F_3(x_i)}{F_6(x_i)}\right) \to \min\limits_{x_i \in X}$	$\mathbf{\frac{15}{35} \cdot \frac{35}{20} = \frac{3}{4} = 0{,}75}$	$\frac{20}{15} \cdot \frac{15}{12} = 1{,}67$	$x_{i0} = x_1$
$F_8(x_i) = \left(\frac{F_4(x_i)}{F_5(x_i)}\right) \to \max\limits_{x_i \in X}$	$\mathbf{\frac{15}{50} \cdot \frac{15}{20} = 0{,}225}$	$\frac{20}{35} \cdot \frac{3}{12} = 0{,}143$	$x_{i0} = x_2$

As we can see, in spite of the fact that it is absolutely objective ($x_1 \succ x_2$), the solution x_2 as $x_{i0} = x_2$ can always be substantiated by one or another surrogate criterion.

2. Methodology

The conceptual foundations of the completed research constitute the methodological principles of forming scenarios for the events development; analytical models for calculating scenario cash flows, shown in deterministic and hyperbolic-reduced model form; application of a multi-criteria (Pareto) theory of decision-making (investment projects, assets); use of volatility estimates to justify authors integral (compromise) optimality criteria. The key theoretical and methodological foundations, concepts, messages that form a scenario approach in the aspect of economic and financial forecasting are presented in numerous fundamental scientific papers by H. Kahn [1,2], P. Schoemaker [3], P. Schwartz [4], R. Ayres

[5], F. Knight [6], G. Ashworth [7]. Applied aspects of definition, formation, calculation and application of cash flows in investment, financial and foreign exchange markets are extensively presented in the works of A. Damodaran [8], R. Brealy [9], J. Van-Horne [10], F. Cheng [11], optimization models were considered by V.D. Vasiliev [12].

2.1 Manipulations and Advanced Criterial Models

Let’s show some clean and as well as mixed manipulative directions that "improve" the criterion evaluations for selecting the "correct and unique" . Here are some components of this "gentleman’s" set:

- changing the team of experts to a more "efficient" group of analysts;
- considering other factors, other assumptions and conditions;
- changing the concept of forming scenario cash flows;
- performing additional studies using advanced forecasting methods and foresight techniques;
- introducing rational adjustments or correction factors that more completely take into account the diverse and multiple causes and peculiarities of cash flow forming;
- increasing the status of the projections as a result of improving the analytical rating, the development of which will be adequately funded;
- refining the estimates of cash flows in scenario formats (for example, by overestimating slightly, but "scientifically" CF_{ti2});
- changing CFк scale for other scales, for example, (B - balls), (U - usefulness).

In our opinion, the following concept of choosing $x_{i0} \in X$ is the most reasonable.

Let:

$CF_{tj}(x_i)$ – value of cash flow in t period for j scenario while selecting decision $x_i \in X$;

U_t – utility function (in the context of hyperbolic discounting) of the cash flow unit in t period $(0 \le U_t \le 1)$, $(U_{t+1} < U_t < U_{t-1} < \cdots < U_1 < U_0 = 1)$;

$S_j \in S = (S_j, j = \overline{1;m})$ – scenarios from the full set of incompatible events that will happen with probabilities greater than zero;

CF^* – desirable (acceptable, sufficient, favorable, comfortable etc) CF value for a top manager (LPR – decision-maker);

$M_t^{(i)} = (j / CF_{tj}(x_i) \ge CF^*, j = \overline{1,m}; t = \overline{1,T})$ – subset of favorable scenario numbers for t period while selecting decisions $x_i \in X$;

$N_t^{(i)} = (j / CF_{tj}(x_i) < CF^*, j = \overline{1,m}; t = \overline{1,T})$ – subset of unfavorable scenario numbers for t period while selecting decisions $x_i \in X$;

λи $(1-\lambda)$ – coefficients of relative importance $(0 < \lambda < 1)$ of CF values for subsets $M_t^{(i)}$ и $N_t^{(i)}$ respectively.

The authors suggest the following objective criteria for selecting $x_{i0} \in X$.

$$F_9(x_i) = \frac{\lambda \sum_{t=1}^{T} U_t \sum_{j \in M_t^{(i)}} \left| CF_{tj}(x_i) - CF^* \right|^K}{(1-\lambda) \sum_{t=1}^{T} U_t \sum_{j \in N_t^{(i)}} \left| CF_{tj}(x_i) - CF^* \right|^K} \to \max_{\begin{cases} x_i \in X \\ K \ge 1 \end{cases}}; \tag{9}$$

$$F_{10}(x_i) = \frac{\lambda \min\limits_{1 \le t \le T} U_t \sum_{j \in M_t^{(i)}} \left| CF_{tj}(x_i) - CF^* \right|^K}{(1-\lambda) \max\limits_{1 \le t \le T} U_t \sum_{j \in N_t^{(i)}} \left| CF_{tj}(x_i) - CF^* \right|^K} \to \max_{\begin{cases} x_i \in X \\ K \ge 1 \end{cases}}; \tag{10}$$

$$F_{11}(x_i) = \frac{\lambda \min\limits_{1 \le t \le T} U_t \min\limits_{j \in M_t^{(i)}} \left| CF_{tj}(x_i) - CF^* \right|^K}{(1-\lambda) \max\limits_{1 \le t \le T} U_t \max\limits_{j \in N_t^{(i)}} \left| CF_{tj}(x_i) - CF^* \right|^K} \to \max_{\begin{cases} x_i \in X \\ K \ge 1 \end{cases}}; \tag{11}$$

$$F_{12}(x_i) = \left(\lambda \sum_{t=1}^{T} U_t \sum_{j\in N_t^{(i)}} \left|CF_{tj}(x_i) - CF^*\right|^K - (1-\lambda) \sum_{t=1}^{T} U_t \sum_{j\in N_t^{(i)}} \left|CF_{tj}(x_i) - -CF^*\right|^K\right) \to \max_{\begin{cases} x_i \in X \\ K \geq 1 \end{cases}}; \tag{12}$$

$$F_{13}(x_i) = \frac{\lambda \sum_{t=1}^{T} U_t \sum_{j\in M_t^{(i)}} \left(\mu^{\left|CF_{tj}(x_i) - CF^*\right|^K} - 1\right)}{(1-\lambda) \sum_{t=1}^{T} U_t \sum_{j\in N_t^{(i)}} \left(\mu^{\left|CF_{tj}(x_i) - CF^*\right|^K} - 1\right)} \to \max_{\begin{cases} x_i \in X \\ K \geq 1 \\ \mu > 1 \end{cases}}. \tag{13}$$

The set of similar criteria of optimality $F(x_i)$ can be substantially expended by using the following works [10,12], and also by introducing probabilities (*P*) for implementing scenarios for two situations:

$$1.\ P_j \in P \in S_p: \begin{cases} \sum_{j=i}^{m} P_j = 1; \\ P \geq 0. \end{cases} \tag{14}$$

$$2.\ P_{tj} \in P_t \in S_p^{(t)}: \begin{cases} \sum_{j=i}^{m} P_{tj} = 1, t = \overline{1;T}; \\ P \geq 0. \end{cases} \tag{15}$$

And then, replacing $CF_{tj}(x_i)$ with mathematical expectations $E(CF)_{ti} = \sum_{j=i}^{m} CF_{tj}(X_i)\, P_j$; $E(CF)_{ti} = \sum_{j=i}^{m} CF_{tj}(X_i)\, P_{tj}$, we obtain modified criteria for selecting decisions under conditions of classical risk [13, 14].

We would like to note that in a situation where cash flows have a focus on minimization (for example, there are only expenses or capital outflows, rent or loan payments etc), then the pessimistic and optimistic scenarios simply change places (get reversed), and all calculation approaches, the schemes and models remain the same.

3. Results

The traditional approach in the format of volatility is based on the assumption that any deviation from the mathematical expectation (or, simply saying, arithmetic average) of any result indicator is viewed negatively . This is a foundation for the following theories: VAR (Value at Risk), COV (covariance), COR (correlation), (the systemic risk factor of W. Sharp - beta in CAPM model), (dispersion).

The authors, with due respect to these methods and their authors- G. Markowitz [15], and W. Sharp [16], have a bit different point of view.

As something "negative", we consider only deviations of values from some accepted comfortable value. Any deviations for a better side are viewed as positive. So only criteria for quantifying these situations and comparing them with each other should be suggested. The authors propose to form the ratio of discounting negative and positive deviations on the hyperbolic utility function. Decisions that make this ratio extreme are declared the best from the position of volatility concept.

Such approach [12, 13, 14, 17] seems natural, reasonable, psychologically consistent, and in some aspects - in relation to risk assessment – it develops the ideas of analytical business calculations from Markowitz and W. Sharp models [15, 16].

Formed author's criteria for selecting solutions within the framework of a formalized conceptual paradigm are, of course, objective implementations of solutions from the field of effective Pareto sets. Thus, author's evaluation models can be considered dominant and rational in comparison with traditional ones.

4. Conclusion

1. The scenario approach expands the analytical capabilities of investigating cash flows in any companies with regard to selection of effective decisions. However, traditionally proposed models for forming optimality criteria have a weak theoretical justification, and their application in business practice can lead to the selection of inefficient, non-Pareto decisions from the field of consent.

2. The models of efficiency criteria proposed by the authors are based on the rational principle of "reasonable sufficiency" as applied to the standard theory of decision-making under conditions of risk and uncertainty. Presented optimality criteria in a formalized form are considered as risk criteria in the paradigm of volatility.

3. Formulated selection problem allows to use other concepts in order to develop the criteria for choosing business decisions: VAR (Value at Risk) model, risk and regret model by L. Savage, utility theory model, curve model by M. Lorenz. The authors suggest to other analysts to work further in this direction and to present the appropriate formalized tools to practicing top managers.

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