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# SENSITIVITY ANALYSIS OF SELECTED FACTORS AFFECTING THE OPTIMIZATION OF THE FUNDS FINANCING RECOVERY FROM PROPERTY DAMAGE ON RESIDENTIAL BUILDINGS

*Abstract:* Paper deals with the optimization of the funds financing recovery from property damage on residential buildings. The optimization is analyzed with respect to three factors: value of property, deductible and amount of debt. The sensitivity analysis is made for three situations characterized by different input parameters and described by ratio indicators Loss Ratio and Cost Ratio. The effect of the optimization is illustrated on a case study and shown on graphs. The effect of optimization lies on the combination of different types of funds and enjoying their advantages. The optimization is made under the condition of ensuring the comprehensive cover. Advantages and disadvantages of particular ex ante and ex post financing methods are discussed.

## Introduction

Increasing frequency and gravity of consequences of natural disasters, connected with global warming, requires attention within the context of large loss burden resulting from mentioned disasters. Term "change of climate" refers to a change in the statistical distribution of weather over periods of time while term "global warming" means the increase in the average temperature of Earth's near-surface air and oceans. The increment of global surface temperature is assessed by 0.76° C since 1850. Occurrence of natural disasters is generally known: tsunami as a series of water waves caused by the displacement of a large volume of a body of water, generated usually by volcanic eruptions, earthquakes or landslides (around 200.000 victims at Indian Ocean tsunami 2004); hurricane (tropical cyclone) as a storm accompanied by strong winds and heavy rain caused by large low-pressure center and numerous thunderstorms (hurricane Katrina with total estimated property damage 81 billion USD 2005); or flood as inundated land by an overflow or accumulation of an expanse of water (2002 European floods in Czech Republic and neighboring countries). Natural hazard can be described by classification system as e.g. Tropical cyclone classifications or Beaufort scale.

The occurrence of natural disasters is uncertain, in other words it is a risk with its certain magnitude of the potential loss $L$ and the probability $p$, that the loss will occur. Risk should be identified, controlled (elimination, substitution, reduction of hazard, minimization of consequences), transferred and financed according to principles of risk management. Risks which cannot be eliminated, substituted or transferred to others entirely (for instance natural risks) should be covered, e.g. by insurance. Such risks are called residual risks.

The paper is focused on risk financing understood as ensuring the economic provision of funds to finance recovery of a natural person / organization from property damage. The most economic choice of alternative form (or combination of alternative forms), of providing finance to meet the consequences of adverse fortuitous events is defined as economic provision. There are several methods of risk financing (insurance, external borrowings, financial reinsurance, contingency reserves and funds); most of them are suitable for big

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companies whereas natural persons can rely just on few of them. Risk financing can be realized by one method or by combination of more methods. Combing the methods shall accentuate advantages of particular methods and suppress their disadvantages.

**Ex Ante Risk Financing**

Ex ante (from Latin for "before the event") funding can be realized by means of insurance or reserves. While ex post funding resolves the distribution of the loss burden after the event, ex ante approach resolves it before the act. Insurance is based on solidarity principle, reserves on foresight principle. Victims aren't depended on the goodwill of others and ex ante approach motivates prevention.

Insurance is defined as the equitable transfer of the risk of a loss, from one entity to another (usually from insured to insurer), in exchange for a premium, and can be thought of as a guaranteed small loss to prevent a large, possibly devastating loss. Insurance funding doesn't require formation of reserves and money for indemnification are at disposal immediately after the occurrence of insurance event or at least in very short period. On the other hand, the premium can be expensive, indemnification can be limited by insurance terms (e.g. exclusions, upper insurance benefit limit). Certain disadvantages can be reduced, e.g. by granting premium discounts for structural safeguards (especially in fire insurance). Formation of reserves is relatively cheap but accompanied with high implicit costs. Reserves and insurance as ex ante approaches should be preferred since the distribution of the loss burden is made before the event and promote interest in prevention. Creating sufficient amount of reserves in the case of large damages is problematic for natural person hence reserves will not be considered in following text.

Fig. 1. Prevention measures

Fig. 2. Flood in Blansko district 2006

**Ex Post Risk Financing**

Ex post (from Latin for "after the fact") funding stands for collecting money after the occurrence of loss on real property. There are several ways of ex post funding: liquid assets, credit, government subsidies and private donations. Generally, ex post approach seems to have its advantages - the speculative prospect of obtaining adequate compensation without making any own financial contribution. On the other hand, there are weigh heavier disadvantages as explained in following paragraphs. Generally, ex post funding resolves the distribution of the loss burden after the event.

Usage of liquid assets is cheap way of funding, but rarely can ensure comprehensive loss cover. Liquid assets should be used entirely for funding small-scale loss events (covering not insured losses or deductibles related with insured losses). The model (see in [3, 4]) works with presumption that all anticipated future losses pass condition of insurance event, therefore liquid assets comprehend the coverage of deductible expenses.

Credit is expensive way of financing (necessity to pay credit interest) beyond the fact there isn't legal claim to grant a credit. On the other hand man needn't to form reserves and disposable money can be invested in project with potentially high IRR (internal rate of return).

Specific forms of ex post risk financing are government subsidies and private donations. Those forms are very uncertain, since victims are dependent on the goodwill of others, on political decision-making process. Especially small-scale losses are not spectacular enough to trigger government subsidies or private donations. It's also problematic to allocate financial aid fairly among those in need. Government subsidies are followed with heavier tax burden on the country as whole. Individuals who had voluntarily arranged insurance or who donated money for victims are asked to pay twice. Taking into consideration mentioned facts government subsidies and private donations will not be considered in following text.

Generally, ex post funding can't guarantee comprehensive cover, often causes delay in reconstruction and owner's interest in prevention is downgraded.

**Optimization Model of the Funds Financing Recovery**

The model used for sensitivity analysis has been published and described in detail way in Nehnuteľnosti a bývanie nr. 1/2009 in paper named „How to Ensure Sufficiency of Financial Backing to Cover Future Losses on Residential Buildings in Efficient Way?" [4]. The model is reminded briefly in following text.

Main idea lies in suppression disadvantages and enjoying advantages of various methods of funding. The model takes into consideration two ex ante methods (insurance and savings or reserves) and one ex post method (credit). Insurance is considered as the most important component of the model. Two conditions are satisfied:

1) To ensure entire funds financing recovery (funds consist of insurance benefit, own savings, interest from invested savings, credit and payments arising from insurance policy: indemnification over upper insurance benefit limit *PIBL* and deductible *DP*);
2) To ensure efficiency of costs connected with the creation of funds, i.e. minimization the costs *TC* (premium payments *TP*, payments arising from insurance policy, savings $A_S$, credit and credit interest *AC*).

$$TC = TP + \sum_{0}^{k} PIBL + \sum_{0}^{l} DP + \sum_{1}^{n} A_S + \sum_{1}^{p} AC \qquad (1)$$

The model analysis each situation within 1.225 particular combinations according to ratio insurance / credit / savings within the frame of costs connected with the creation of the funds. The model has been simplified for this sensitivity analysis and takes into account only 2 methods of funding: insurance and credit. Therefore, previous formula (1) is converted:

$$TC = TP + \sum_{0}^{k} PIBL + \sum_{0}^{l} DP + \sum_{1}^{p} AC \qquad (2)$$

and the formula for *TP* [4] is converted in the same way by removing savings:

$$TP = n * \left\{ VP * \frac{\sum_{1}^{m} PL_j - AC * \frac{(1+r)^p - 1}{(1+r)^p * r}}{\sum_{1}^{m} PL_j} \right\} * \left( BIR + FIR_B * k_i \right) * \qquad (3)$$

$$* \left( \frac{100 - DIS}{100} \right) * \left( \frac{100 + ADD}{100} \right) * \left[ 1 - \frac{1}{720} * \{ 40{,}228 * \ln(x) - 158{,}58 \} \right]$$

| Symbol | Description | Unit of measure |
|---|---|---|
| **TP** | Total premium | Currency |
| **N** | Duration of examined period | Years |
| **VP** | Value of property | Currency |
| **$PL_j$** | Particular loss | Currency |
| **M** | Amount of losses during examined period | - |
| **AC** | Credit annuity | Currency |
| **R** | Annual credit interest rate | % |
| **P** | Term of credit expiration | Years |
| **BIR** | Basic elemental insurance rate | % |
| **$FIR_B$** | Flood insurance rate for basic (1st) flood zone | % |
| **$k_i$** | Flood zone ratio | - |
| **x** | Deductible value | Currency |
| **DIS** | Deductions from premium | % |
| **ADD** | Additional premium | % |

When taking into account solely insurance and credit, factors affecting the efficiency of funds are (under specified limiting conditions, see [4]):

- duration of examined period,
- value of property,
- loss frequency,
- extent of particular losses,
- location,
- extent of insurance coverage (insured hazards),
- flood zone,
- sum insured,
- deductions from premium (e.g. fire-resistant materials),
- additional premium (e.g. insufficient security against theft),
- premium amount,
- deductible value,
- upper insurance benefit limit.
- interest rate of credit interest,
- ability to repay the debt.

**Case Study - Sensitivity Analysis of Selected Factors**

Sensitivity analysis is focused solely on three factors: value of property, deductible and amount of debt although it's clear that all factors mentioned above has its own impact on the model. All three variables have discrete probability distribution. Sensitivity analysis is processed on case study with following parameters:

| Symbol | Description | Value |
|---|---|---|
| **-** | Type of property | Family house |
| **N** | Duration of examined period | 40 years |
| **VP** | Value of property | <1.000.000; 10.000.000> CZK |
| **$PL_j$** | Particular loss: nr. 1<br>nr. 2<br>nr. 3<br>nr. 4 | 140.000 CZK<br>520 CZK<br>2.000 CZK<br>12.500 CZK |
| **R** | Annual credit interest rate | 7 % |
| **$C_{max}$** | Max amount of annual installment of credit including interests | 10.000 CZK |
| **$k_i$** | Flood zone ratio (according to respective fl.zone) | 1 (flood zone) |
| **x** | Deductible value | <500; 40.000> CZK |
| **DIS** | Deductions from premium | 0 % |
| **ADD** | Additional premium | 0 % |
| **UIBL** | Upper insurance benefit limit | 2.000.000 CZK |
| **$C_{real}$** | Optimized amount of credit | <0; 150.000> CZK |

The comparison is processed through two ratio indicators defined as:

Loss Ratio (*LR*)

$$LR = \frac{\sum_{i}^{m} PL_j}{VP} \tag{4}$$

Cost Ratio (*CR*)

$$CR = \frac{TC}{VP} \tag{5}$$

whereas (*SI* stands for Sum Insured)

if $C_{max} = 0$ than $$VP = SI \tag{6}$$

and if $C_{max} > 0$ than $$VP > SI \tag{7}$$ [2]

Regression functions are displayed for both *LR* and *CR* values in following graphs within 3 different situations.

Situation 1:

Variable *VP* is entered in input form on interval <1.000.000; 10.000.000> CZK;
Variable *x* is constant <1.000; 1.000> CZK;
Variable $C_{real}$ is constant <0; 0> CZK.

Situation 2:

[2] Value *SI* is calculated by model according to optimized credit value, this stands just for Situation 3 where $0 \leq C_{real} \leq 150.000$

Variable *VP* is entered in input form on interval <1.000.000; 10.000.000> CZK;
Variable *x* is optimized by model on interval <500; 40.000> CZK;
Variable $C_{real}$ is constant <0; 0> CZK.

Situation 3:

Variable *VP* is entered in input form on interval <1.000.000; 10.000.000> CZK;
Variable *x* is optimized by model on interval <500; 40.000> CZK;
Variable $C_{real}$ is optimized by model on interval <0; 150.000> CZK.

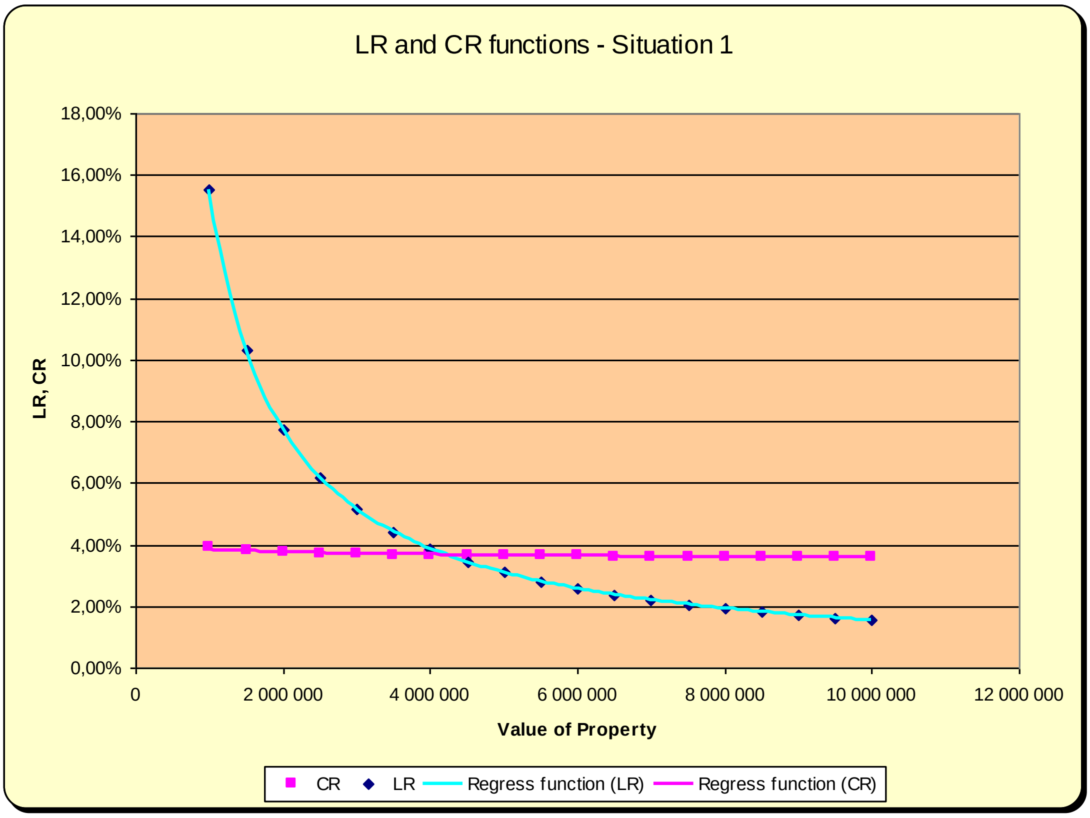


*Fig. 3: LR and CR functions – Situation 1*

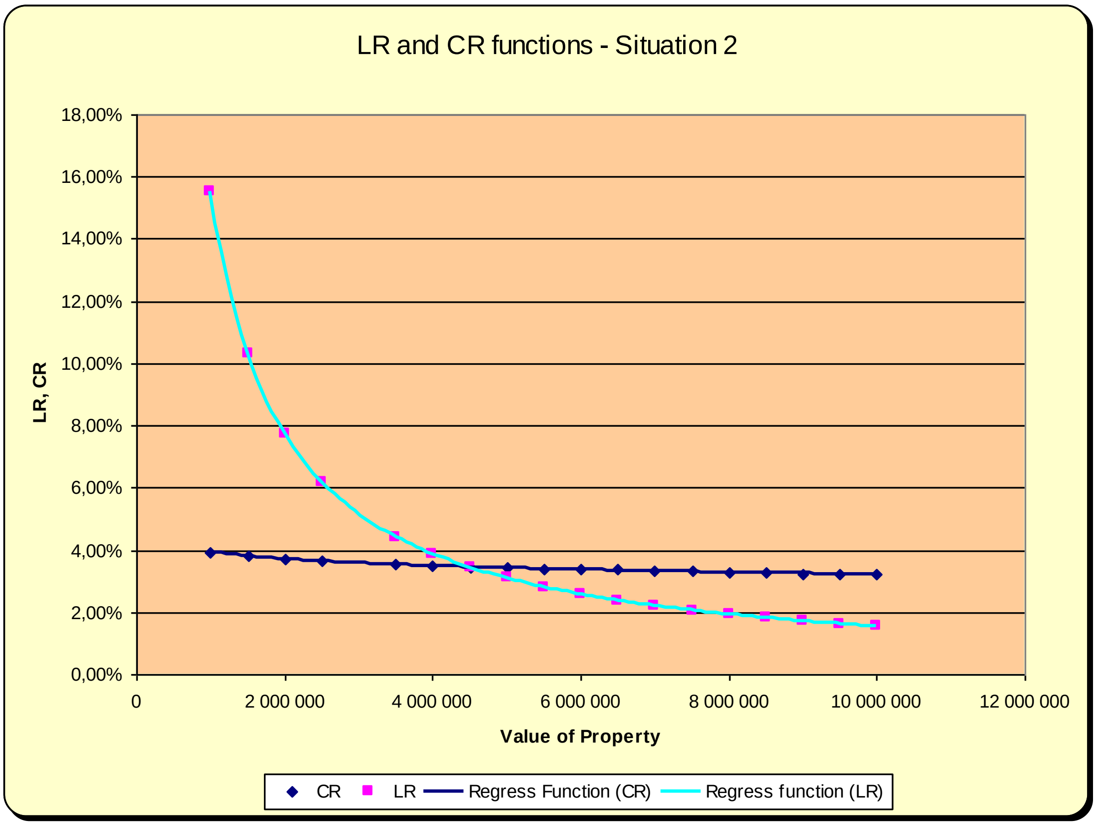


*Fig. 4: LR and CR functions – Situation 2*

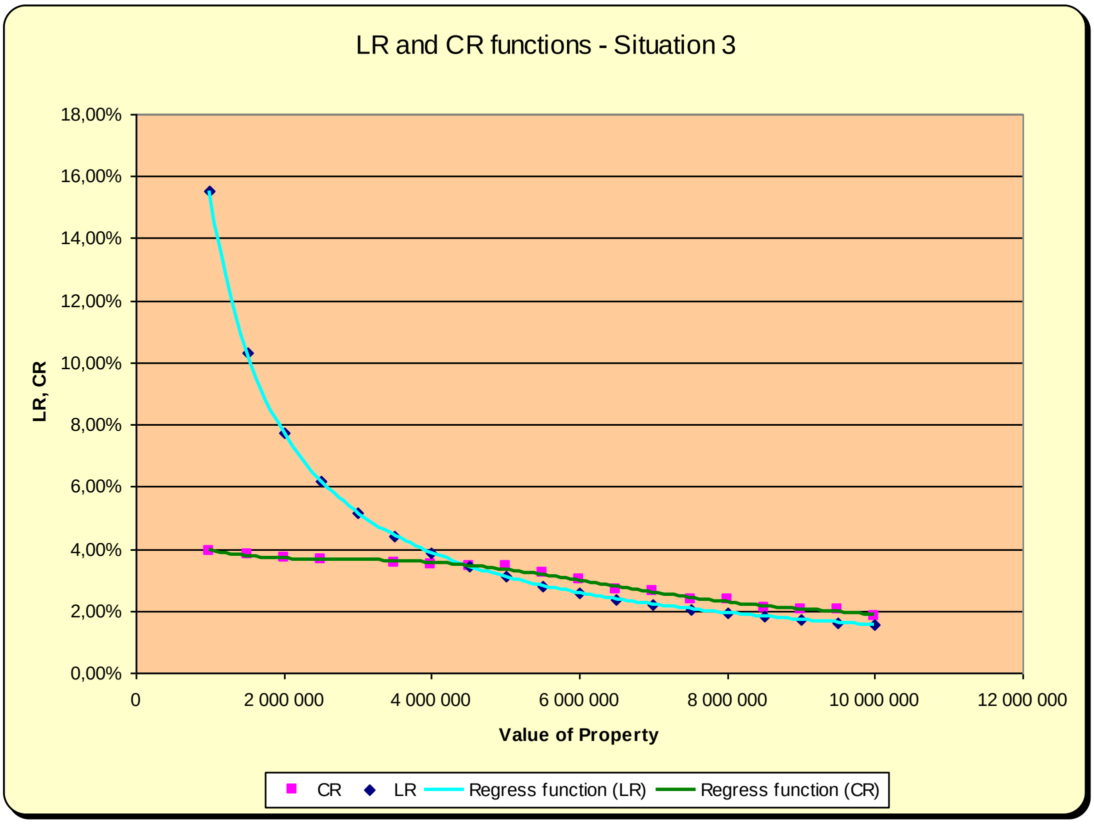


*Fig. 5: LR and CR functions – Situation 3*

## Conclusion

Case study shows the impact of 3 factors (value of property, deductible and amount of debt) on the optimization of the funds financing recovery from property damage on residential buildings. Sensitivity analysis is processed through two ratio indicators: Loss Ratio (*LR*) and Cost Ratio (*CR*). The goal of insured is to pay as less as possible; on the other hand there should be passed condition of comprehensive cover of all anticipated losses. Hence, according to respective conditions favourable situation happens if

$$LR > CR. \qquad (8)$$

In the case study such situation stands for the condition when LR > 3,68 % (valid for **Situation 1** described by curves LR and CR1 Figure 3). If *LR* < 3,68 % the ordinary insurance becomes ineffective. First step, how to improve the efficiency of the insurance is to optimize the deductible value (**Situation 2** described by curves LR and CR2, Figure 4). The optimization of deductible value is difficult since it requires complicated and time-consuming calculation. Optimization should be done by using above mentioned model. In such case the condition of efficiency (see quotation nr. 8) is extended to *LR* > 3,46%. The effect of optimized deductible value is sensible but not sufficient enough.

The problem is that the decrement of *LR* is higher than decrement of *CR*. To make the funds efficient for LR < 3,46 % it is necessary to add another type of financial backing (**Situation 3** described by curves LR and CR3, Figure 5). This paper discusses just the credit, but reserves can be used as well. Even if *LR* < *CR*, credit causes the change of the slope of the *CR* curve and thus decidedly reduces non-efficiency of sole insurance.

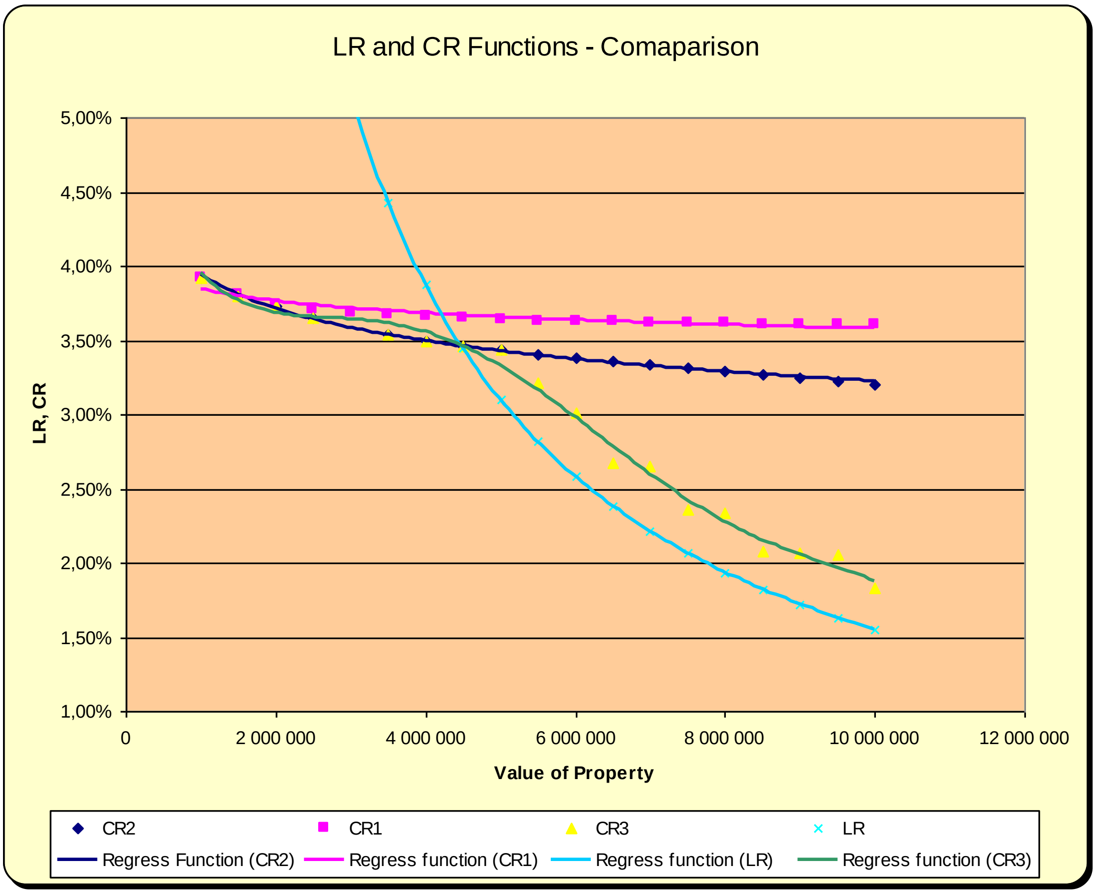


*Fig. 6: Comparison of Situation 1, 2 and 3 in the graph*

Optimization of the funds is shown on Figure 6. The graph illustrates the effect of the combination of particular types of financial backing made by the mathematical model. Achieved results are valid solely for solved case study. For different parameters (value of the property, loss burden, …) the achieved results will be different. Nevertheless the principle of the model lies on the change of the slope of the curve *CR* by means of adding and optimizing various types of funds. The optimization is made under the condition of ensuring the comprehensive cover. The impact of the model on the optimization will be more distinctive when taking into account the flood exposure of particular area expressed by means of insurance flood zones and by another type of funding – reserves.

**Literature**


[1] Česká asociace pojišťoven: "Tiskové zprávy". Praha: Webové stránky České asociace pojišťoven, 2004. [online] Url: http://www.cap.cz.

[2] Ducháčková, E.: "Komerční pojištění a krytí povodňových škod". K řešení povodňového rizika pojištěním. Proceedings. VŠE Praha, 2003. ISBN: 80-245-0644-0.

[3] Hanák, T. *Modelování optimální struktury zdrojů finančního krytí škod na pojišťovaných stavbách*. Disertační práce. Brno: VUT FAST Brno, 2007. s. 1-131. Školitel: doc. Ing. Alena Tichá, Ph.D.

[4] Hanák, T. How to Ensure Sufficiency of Financial Backing to Cover Future Losses on Residential Buildings in Efficient Way?, Nehnuteľnosti a bývanie, Vol. 4, pp. 42-51. ISSN: 1336- 944X.

[5] Hanák, T.; Tichá, A. Flood losses on buildings and related insurance aspects, In *8th international conference Organization, Technology and Management in Construction*. Umag, Croatia: Croatian association for Organization in Construction, 2008. s. 23 (1 s.). ISBN: 953-96245-8-4.

[6] Hanák, T.; Vítková, E.; Hromádka, V. Flood losses financing and disposable financial sources for realization of anti-flood operations leading to their minimization, In *Civil Engineering – Science and Practice International Conference 2008*. University of Montenegro, 2008, pp. 1217-1222, ISBN: 978-86-82707-15-8.

[7] Korytárová, J.; Aigel, P.; Hanák, T.; Hromádka, V.; Marková, L.; Puchýř, B.; Šlezingr, M.; Uhmennová, H.; Tichá, A. Povodně a nemovitý majetek v území. Práce a studie Ústavu stavební ekonomiky a řízení FAST VUT v Brně. Práce a studie Ústavu stavební ekonomiky a řízení FAST VUT v Brně. Brno: CERM, 2007. 181 s. ISBN: 978-80-7204-573-0.

[8] Korytárová, J., Fridrich, J., Puchýř, B. *Ekonomika investic*. VUT v Brně, Fakulta stavební, 2001. 227 s. ISBN: 80-214-2089-8.

[9] Korytárová, J.; Šlezingr, M.; Uhmannová, H. Determination of potential damage to representatives of real estate property in areas afflicted by flooding, *Journal of Hydrology and Hydromechanics*, 2007, Vol. 2007/4, p. 282-285. ISSN: 0042-790X.

[10] Menzinger, I., Brauner, C. *Floods are insurable!* Swiss Reisnurance Company. Zuchyr, Switzerland, 2002, pp. 1-8.

[11] Ministerstvo zemědělství České republiky: "Posílení rizikové analýzy a stanovení aktivních zón v českém vodním hospodářství". Webové stránky Ministerstva zemědělství České republiky, 2004. [online] Url: http://www.mze.cz.

[12] Montana's Official State Website: *2007 Biennium Executive Budget*, pdf file. http://mt.gov/budget/budgets/2007_budget/7)%20InsuranceTax%20OCTober%20FY04.pdf

[13] Shim, J., Siegel J., *Dictionary of Economics*. John Wiley & Sons, Inc. New York, 1995, p. 373. ISBN: 0-471-01314-5.

[14] Tichá, A.; Korytárová, J. The evaluation of flood loss according to the area property

indexes. In *Organization, technology and management in construction.* Zadar, Croatia: Croatian association in Construction, 2006. p. 57. ISBN: 953-96245-6-8.

[15] Tichá, A., Marková, L., Puchýř, B. *Ceny ve stavebnictví I, rozpočtování a kalkulace*. Brno, ÚRS Brno. 1999. 206 s.

[16] Wikipedia, the Free Encyclopedia. Wikimedia Foundation, Inc. Available from: http://en.wikipedia.org/wiki/Main_Page .

[17] Zákon č. 37/2004 Sb., o pojistné smlouvě a o změně souvisejících zákonů.

[18] Zákon č. 12/2002 Sb., o státní pomoci při obnově území postiženého živelní nebo jinou pohromou, ve znění pozdějších předpisů.