INTRODUCTION

The art of identifying and effectively managing risk in a timely manner has become an integral part of strategic management. Property developers who are unable to identify the scope and consequences of related risks and who consequently fail to introduce efficient mechanisms to manage those risks, clearly jeopardise the stability not only of their investments but also their overall success. The level of risk rises in proportion to the level of the difficulty and scope of the whole investment. Therefore, these risks need to be examined, predicted, analysed, and quantified as the investment is prepared and finalised. Individual phases of the risk management process in property development are shown in Figure 1.

PARAMETERS NECESSARY FOR RISK QUANTIFICATION AND RISK MODELLING

The quantification of risks is the part of risk analysis that describes and numerically evaluates the impact of potential threats. The main goal of risk quantification is to estimate the frequency, probability, and significance of potential losses associated with a particular project. In analysing risk, property developers work with parameters that in most cases cannot be accurately measured. Their values are often based on the estimates of experienced professionals. For the purpose of risk quantification, property developers need to determine the parameters as accurately as possible. The following two basic parameters are used:
9RISK MODELLING IN THE PROPERTY DEVELOPMENT PROCESS

a) Probability of the occurrence of the risk is closely related to the term ‘degree of risk’. Phenomena with highly probable losses are regarded as more risky than those with lower probabilities. If we view risk as the likelihood of an unfavourable deviation from the expected and desired result, then the degree of risk will be measured based on the probability of such unfavourable deviation occurring. Probabilities of accidents in road, air, and sea transport offer one example. Road transport is accountable for the highest share of accidents - about 60% - followed by sea and air transport with a 30% and 10% share respectively. By applying this concept of probability as an unfavourable deviation from the desired result, we perceive that the risk of accident rate in sea transport is higher than air transport, but at the same time lower than road transport. The higher the probability of an unfavourable event, the higher the probability of a deviation from the desired result, hence the higher our risk.

b) Estimated (expected) value of loss on an investment is based on two parameters: probability of the occurrence of a loss, and magnitude of the potential loss. For example, if the amount of 20 monetary units (MU) is subject to risk and the probability of loss is 0.3, then the probable value of the loss will be 6 MU. An important factor here is time. Both the value of a loss and the probability of an event the occurrence change over time. The amount of probable loss $Z(t)$ within the time interval $\langle 0, T \rangle$ can be calculated as

$$Z(r(t), v(t)) = \int_0^T r(t)v(t)\,dt,$$

where

$r(t)$ – risk function in time $t$ expressed as the probability within the interval $(0, 1)$;
$v(t)$ – loss function in time $t$ (in practice, a jump function is often used and assumes values of 0 or 1), [12];
$Z(t)$ – magnitude of probable loss within the time interval $(0, T)$, which we attempt to optimise, i.e. to find the minimum of the given function $Z(t)$.

Our goal in Figure 2 is to minimise the volume under the $Z(t)$ area. The amount of vacation which is taken by a developer’s staff may serve as an example. During a year, vacations are usually taken in June, July, and August. Therefore these months represent the highest loss for the company (bad management decisions, cost of wages, etc.). The $Z(t)$ function will therefore assume its highest values in the aforementioned months. An integral part of risk quantification is to determine the statistical characteristics of risks. The most widely used instruments for risk quantification include maximum expected return, root mean square deviation, coefficient of variation, and variance. The most common method used in analysing risk is based on the criterion of expected average profit as the indicator of estimated profitability combined with the variance, or root mean square deviation of the profits, as the indicator of risk.

**Expected return**

To compare the profitability of alternative investments within a given risk environment, a new measure needs to be introduced - expected return $E(x)$ - which is defined as the mean value of the returns

$$E(x) = \sum_{i=1}^{n} x_i p_i,$$

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The expected return measures only the potential amount of the return (profit). Therefore, it may only be regarded as an indicator of the return (profit). It does not say anything about the certainty of the achieved amount of the return (profit), or the risk associated with such a return (profit). In most cases, as the following example shows, the expected return cannot be the basis for making a decision as to whether a particular investment is appropriate. Suppose two investment projects A and B with $x_i$ returns and $p_i$ probabilities of attaining such returns, as shown in Table 1 below:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>E(Xa)</th>
<th>E(Xb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>1,100</td>
<td>0.2</td>
<td>1,220</td>
</tr>
<tr>
<td>2</td>
<td>2,000</td>
<td>1,750</td>
<td>0.8</td>
<td>1,400</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>1,620</td>
<td>1,620</td>
</tr>
</tbody>
</table>

The investor cannot make a decision based on the criterion of maximum expected return, since the calculation (2) above yields expected returns of 1,620 MU on both investments. As Table 1 shows, the return for Project A is less stable - hence more risky - than Project B. This fact both justifies and explains the need to introduce an additional criterion (variance) to consider both the profitability and risk associated with each investment project.

Variance

Variance is the measure of the dispersion of returns around their expected value. It represents the range of potential deviations of the actual return from the expected return. The more the actual return differs from the expected return, the greater the deviation. Variance $\sigma^2(X)$ is defined as the mean value of the square of the deviation of potential returns from the expected value $E(X)$, i.e.

$$\sigma^2(X) = E[(X - E(X))^2] = \sum_{i=1}^{n} [x_i - E(X)]^2 p_i = E(x^2) - E^2(X). \quad (3)$$

where

$X$ - random variable, which is the attained return;

$x_i$ - value of $i$-th attained return;

$p_i$ - probability of attaining the value of $x_i$.

As the expected return is expressed as an absolute value in monetary units, we will use the root mean square deviation $\sigma(X)$ in evaluating the results. The root mean square deviation is defined as the principal square root of the variance. Thus, it has the same ‘dimensions’ as the expected return. It is evident that a risk-averse investor deciding between two investments with equal expected returns will choose the one with a lower variance of returns.

**Root mean square deviation**

The root mean square deviation can be expressed as the square root of variance.

$$\sigma = \sqrt{\sigma^2}.$$ \hspace{1cm} (4)

The root mean square deviation is unquestionably the most common instrument used in measuring risk, as it gives a result in the same units as the expected return. This indicator may, for example, represent the maximum amount by which the price of an investment instrument might change during a defined period of time (e.g. one day) at a specific probability level. Thus, for an investment project with a mean value of 2,000 MU and a root mean square deviation of 100 MU ($\pm 5\%$), the minimum and maximum values will be 1,900 MU and 2,100 MU respectively. Should the root mean square deviation assume higher values, the mean value would then become unstable. Though there exists a chance of a higher return, potential losses would be far more painful.

**Mean value – Coefficient of variation**

The coefficient of the variation expresses the level of risk $\sigma$ per one unit of the expected return $E$, thus

$$C = \frac{\sigma}{E}. \quad (5)$$

Suppose the returns on investments A and B as the random variables $X$ and $Y$. Based on the mean value/coefficient of the variation rule, a risk-averse investor will choose investment A, if

$E(X) \geq E(Y)$ and $C(X) < C(Y)$.

The coefficient of the variation expresses the fluctuation of potential revenues with respect to the expected return. The lower the ratio, the more favourable the project seems to be. At the same time, as shown in the example of the two investments in Table 2 below, the amount of the expected return $E(X)$ which relates to the resulting ratio is also important. Clearly, investment B is more profitable than investment A, as even the worst potential result for investment B is better than the return offered by alternative A.
The following property developer’s decision about investments in three different markets may serve as an example of using these instruments. Based on the experience of property development professionals, the company’s management has made estimates of the probability of making a profit on the sale of a residential building in three different markets as shown in Table 3. The property developer’s task is to determine which of these three markets is the best option for this particular investment.

Below is the calculation of the expected return during one period for all three markets:

\[
\begin{align*}
\text{Market 1:} & \quad E(\varepsilon) = 15,000 \cdot 0.5 + 20,000 \cdot 0.6 + 25,000 \cdot 0.2 = 24,500 \\
\text{Market 2:} & \quad E(\varepsilon) = 10,000 \cdot 0.3 + 15,000 \cdot 0.7 + 20,000 \cdot 0.3 = 19,500 \\
\text{Market 3:} & \quad E(\varepsilon) = 17,000 \cdot 0.6 + 22,000 \cdot 0.4 + 26,000 \cdot 0.3 = 26,800
\end{align*}
\]

Below is the calculation of the variance for individual markets:

\[
\begin{align*}
\text{Market 1:} & \quad \sigma^2 = \sum (\varepsilon - E(\varepsilon))^2 \cdot p_i = \\
& \quad = (15,000 - 24,500)^2 \cdot 0.5 + (20,000 - 24,500)^2 \cdot 0.6 + (25,000 - 24,500)^2 \cdot 0.2 = 57,325,000 \\
\text{Market 2:} & \quad \sigma^2 = \sum (\varepsilon - E(\varepsilon))^2 \cdot p_i = \\
& \quad = (10,000 - 19,500)^2 \cdot 0.3 + (15,000 - 19,500)^2 \cdot 0.7 + (20,000 - 19,500)^2 \cdot 0.3 = 43,325,000 \\
\text{Market 3:} & \quad \sigma^2 = \sum (\varepsilon - E(\varepsilon))^2 \cdot p_i = \\
& \quad = (7,000 - 26,800)^2 \cdot 0.6 + (22,000 - 26,800)^2 \cdot 0.4 + (26,000 - 26,800)^2 \cdot 0.3 = 67,032,000
\end{align*}
\]

Calculation of the root mean square deviation for each market:

\[
\begin{align*}
\text{Market 1:} & \quad \sigma = \sqrt{\sigma^2} = \sqrt{57,325,000} = 7,571.32 \\
\text{Market 2:} & \quad \sigma = \sqrt{\sigma^2} = \sqrt{43,325,000} = 6,542.84 \\
\text{Market 3:} & \quad \sigma = \sqrt{\sigma^2} = \sqrt{67,032,000} = 8,187.30
\end{align*}
\]

Calculation of the coefficient of the variation for each market:

\[
\begin{align*}
\text{Market 1:} & \quad C = \frac{\sigma}{E(\varepsilon)} \cdot 100\% = \frac{7,571.32}{24,500} \cdot 100\% = 30.90\% \\
\text{Market 2:} & \quad C = \frac{\sigma}{E(\varepsilon)} \cdot 100\% = \frac{6,542.84}{19,500} \cdot 100\% = 32.96\% \\
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A summary of the calculations is shown in Table 4.

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\end{align*}
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Calculation of the coefficient of the variation for each market:

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A summary of the calculations is shown in Table 4.
investment decisions for periods of two or three years. One of the most basic instruments used in making such decisions are the
criteria of net present value (NPV) and the internal rate of return
(IRR). Both are time discounted methods of measuring the benefit
of investments. They are based on the assumption that we have an
exact knowledge of the cost and return of investment alternatives.

The net present value is the difference between the total expected
cash flows in individual years over a projects lifecycle, discounted
to their present value using the applicable discount rate and initial
cost of the investment, i.e.

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+k)^t} - I_0,$$

where $C_t$ – net present value of cash flows at the end of the $t$-th
period,

$I_0$ – initial cost of investment,

$k$ – discount rate (expected return on investment),

$n$ – period of project lifecycle.

Under the assumption that the goal of the company is to maximise
shareholder value, the company’s decision based on the NPV
criterion will be as follows:
If NPV is positive, the project is acceptable;
if NPV is negative, the project is rejected; and
if there are several investment options, the project with the highest
NPV is chosen.

Internal rate of return (IRR) is the discount rate $R$ at which the net
present value of the net cash flows $C_t$ equals its initial investment
cost $I_0$. Thus the IRR is equal to the value of $R$ that expresses the
project’s internal rate of return as calculated by the following
equation:

$$\sum_{t=1}^{n} \frac{C_t}{(1+R)^t} = I_0. \tag{7}$$

When evaluating several mutually independent investment projects,
both criteria provide the same results, i.e., lead to the same
investment decision (i.e., rejecting or accepting the project). The use
of IRR is based on the following analysis. The project is acceptable
if it has a positive NPV, i.e., if

$$\sum_{t=1}^{n} \frac{C_t}{(1+k)^t} > I_0, \tag{8}$$

In such a case, the IRR of the same project equals the value of $R$
achieved by substituting equation (7) into (8). Thus,

$$\sum_{t=1}^{n} \frac{C_t}{(1+R)^t} < \sum_{t=1}^{n} \frac{C_t}{(1+k)^t}, \text{ then } R > k.$$

If the net present value of the project is positive, $R$ will be higher than
$k$. If the net present value equals zero, then $R$ is equal to $k$. Finally, in
the case of a negative net present value, $R$ is lower than $k$.
Unlike NPV, which may vary depending on the selected discount
rate, the project’s IRR remains fixed.
The criterion for making a decision using IRR is therefore based on the
comparison of the discount rate $k$ and the minimum desired rate
of return $R$.
If $R > k$, the project is acceptable.
If $R < k$, the project is rejected.
Thus, the project is acceptable if IRR $> k$.

Problems can occur when using the above two profitability measures
in the case of mutually dependent investment projects, as the NPV
and IRR methods can yield differing project rankings. These
differences may result from the scope of an investment (which is
not taken into account by IRR), the timing of cash flows, or differing reinvestment assumptions. NPV is generally regarded as a better criterion, since unlike IRR it reflects the amount of profit expressed in absolute terms and not only profitability.

### 3 Sensitivity Analysis

Sensitivity analysis appears to be the most commonly used project evaluation method.

**Task:** Suppose a property developer’s investment of SKK 100 million for a period of two years \( t = 1, 2 \) with a zero initial cost and an expected rate of return at 15%, which already includes inflation. The developer’s best estimates of cash flows are summarised in Table 5. Gross revenue \( R \) represents the cash flow from the investment over a period of one year.

Table 5. Structure of the investment’s cost and cash flows

<table>
<thead>
<tr>
<th>Gross revenue ( R )</th>
<th>100 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost:</td>
<td></td>
</tr>
<tr>
<td>Land: ( C_1 )</td>
<td>42.505 million</td>
</tr>
<tr>
<td>Engineering: ( C_2 )</td>
<td>2.12 million</td>
</tr>
<tr>
<td>Project design: ( C_3 )</td>
<td>4.03 million</td>
</tr>
<tr>
<td>Contractor: ( C_4 )</td>
<td>36.345 million</td>
</tr>
<tr>
<td>Total cost ( \Sigma C_i )</td>
<td>85 million</td>
</tr>
<tr>
<td>Pre-tax annual return</td>
<td>15 million</td>
</tr>
<tr>
<td>Tax 19 % on SKK 15 million</td>
<td>2.85 million</td>
</tr>
<tr>
<td>Net annual return</td>
<td>12.15 million</td>
</tr>
</tbody>
</table>

By this analysis, the company is aiming for the best possible estimate of its revenues and cost. Based on the resulting estimates, NPV and IRR are calculated. Subsequently, the sensitivity of NPV to potential errors in gross revenue and individual cost item estimates is examined. The following example explains the principle of sensitivity analysis. First, we will make the company’s estimate of the project’s NPV:

\[
NPV = \sum_{t=1}^{\infty} \frac{(1-T_c)R}{(1+k)^t} - \sum_{t=1}^{\infty} \frac{(1-T_c)C_1}{(1+k)^t} - \ldots - \sum_{t=1}^{\infty} \frac{(1-T_c)C_4}{(1+k)^t},
\]

where

\( T_c = \text{tax, } (1-T_c) = (1-0.19) = 0.81 \)

and

\[
R = 100 \text{ million, } C_1 = 42.505 \text{ million, } C_2 = 2.12 \text{ million, } C_3 = 4.03 \text{ million, } C_4 = 36.345 \text{ million (SKK)};
\]

then,

\[
NPV = 0.81 \left[ \frac{100}{(1+0.15)^1} - 0.81 \left( \frac{42.505}{(1+0.15)^1} \right) - 0.81 \left( \frac{2.12}{(1+0.15)^1} \right) - 0.81 \left( \frac{36.345}{(1+0.15)^1} \right) \right] = 131.8275 - 56.033 - 2.791 - 5.312 - 47.91 = 19.75 \text{ million (SKK)}.
\]

Ceteris paribus, the new estimate of the net present value \( NPV_\alpha \) will be:

\[
NPV_\alpha = NPV + (1-T_c) \sum_{i=1}^{\infty} \frac{\alpha \cdot R}{(1+k)^t},
\]

where \( \alpha = \{1\%, 2\%, \ldots, 15\%\} \).

In equation (10) the numerator \( R \) will be stepwise substituted by the values \( C_1, \ldots, C_4 \) provided in Table 5.

Due to increasing prices we will only suppose the case \( \alpha > 0 \Rightarrow NPV_\alpha > NPV, \alpha < 0 \Rightarrow NPV_\alpha < NPV \).

Due to increasing prices we will only suppose the case \( \alpha > 0 \), i.e. \( NPV_\alpha > NPV \) for \( \alpha = \{1\%, 2\%, \ldots, 15\%\} \).
The objective of the analysis will be attained if the property developer does not decrease the 15% expected rate of return. If the individual cost items change, the NPV of the project will also change. Gross revenue depends on the inflation rate which, according to the National Bank of Slovakia (NBS), is currently at 2-3%. Thus, ceteris paribus, NPV will grow as described in Table 6 – i.e., from SKK 19.75 million to SKK 39.50 million. If the value of the considered cost $C_1$ to $C_4$ grows at a rate of 2-3%, such growth will be significantly lower than the growth at a gross revenue of $R$, since $C_1$ to $C_4$ represent lower values; hence their changes will be lower as well. If the prices of individual cost items were to grow at different rates, we would first adjust NPV for the given $\alpha$ and the appropriate cost item for $\text{NPV}_\alpha$. We would then calculate $\text{NPV}_\alpha$ with respect to changes in the next cost item. Once we incorporated all the changes, the resulting $\text{NPV}_\alpha$ would give us the net present value of the whole property development process. With the currently assumed two year investment period, a situation might ensue where the price of land grows by as much as 50% and the cost items $C_1$ to $C_4$ by a maximum of 2-7% on an annual basis. Our calculation is based on the data shown in Table 7.

Table 6. Sensitivity analysis of the project’s NPV with respect to deviations $\alpha$.

<table>
<thead>
<tr>
<th>Estimate error</th>
<th>Revenue R</th>
<th>Land $C_1$</th>
<th>Engineering $C_2$</th>
<th>Project design $C_3$</th>
<th>Contractor $C_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>$R$</td>
<td>$C_1$</td>
<td>$C_2$</td>
<td>$C_3$</td>
<td>$C_4$</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------</td>
<td>------------</td>
<td>------------------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>0.00</td>
<td>19.75000</td>
<td>19.75000</td>
<td>19.75000</td>
<td>19.75000</td>
<td>19.75000</td>
</tr>
<tr>
<td>0.01</td>
<td>21.0668251</td>
<td>20.30972</td>
<td>19.77792</td>
<td>19.80307</td>
<td>20.22860</td>
</tr>
<tr>
<td>0.02</td>
<td>22.38365</td>
<td>20.86943</td>
<td>19.80583</td>
<td>19.85614</td>
<td>20.70720</td>
</tr>
<tr>
<td>0.03</td>
<td>23.7004753</td>
<td>21.42915</td>
<td>19.83375</td>
<td>19.90920</td>
<td>21.18580</td>
</tr>
<tr>
<td>0.04</td>
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The following holds for $R$ at a growth rate of $\alpha = 3\%$ (see Table 7):

\[
\text{NPV}_\alpha = 19.75 + 3.95048 = \text{SKK 23.73048 million}
\]

For other calculations, $\text{NPV}$ will be replaced by $\text{NPV}_\alpha$. As per Table 7, we will set $\text{NPV}$ growth as follows:

$C_1$ – land (50% annual growth, $\alpha_1 = 0.5$) 27.985 (Table 7),
$C_2$ – engineering (2% annual growth, $\alpha_2 = 0.02$) 0.055 (Table 7),
$C_3$ – project design (4% annual growth, $\alpha_3 = 0.04$) 0.212 (Table 7),
$C_4$ – contractor (7% annual growth, $\alpha_4 = 0.07$) 3.350 (Table 7).

For cost items $C_1$ to $C_4$, the NPV will grow by

\[
(1-\tau_j)\sum_{i=1}^{5} \frac{\alpha_i C_i}{(1+k)} = 0.81 \times (27.985+0.055+0.212+3.350) = 0.81 \times 31.602 = 25.597
\]
If $NPV_R$ is the change in the net present value of the gross revenue, and $NPV_{C_1, C_2, C_3, C_4}$ is the change in the net present value with respect to $C_1, ... , C_4$ for a relevant $\alpha$, then

$$NPV_{\alpha} = NPV_{R} - NPV_{C_1, C_2, C_3, C_4} = 23.73 - 25.597 = -1.867.$$

Thus the net present value of this property development project is negative, and the internal rate of return (IRR) is lower than the expected rate of return of 15%. Therefore, the management of the property development project has two options: either to decrease the expected return on capital or to request the investment company to increase the gross revenue $R$ to a level corresponding to a positive net present value ($NPV$).

5 CONCLUSION

The art of mastering risk management in the property development process represents a successful investment for all property developers. Risk management embraces also risk analysis, part of which is risk quantification itself. The risk quantification enables property developers to measure risks and consequently, to quantify their value. The risk quantification is of cardinal importance for property developers, especially when evaluating the risks of any investment project. The use of statistical parameters, such as the expected return, variance, root mean square deviation and mean value – coefficient of variation may serve as an example. In addition to the above mentioned statistical parameters a sensitivity analysis method is frequently used as well. This method helps property developers to determine the estimate of the total revenue and cost for any concrete project as accurately as possible. By means of the net present value and its sensitivity to potential errors in gross revenue and individual cost item estimates, property developers decide on possible investment realization.

<table>
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<th>Estimation error</th>
<th>$\sum_{t=0}^{T} \frac{\alpha R}{(1 + k)^t}$</th>
<th>$\sum_{t=0}^{T} \frac{\alpha C_i}{(1 + k)^t}$, $i = 1, \ldots, 4$</th>
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REFERENCES