Conference Paper

Holistic enterprise risk management - risk coverage and risk control
CIB2007-121

Author(s):
Girmscheid, Gerhard

Publication Date:
2007

Permanent Link:
https://doi.org/10.3929/ethz-a-005996563

Rights / License:
In Copyright - Non-Commercial Use Permitted
Holistic Enterprise Risk Management - Risk coverage and risk control

Prof. Dr.-Ing. Gerhard Girmscheid

ABSTRACT
The present and future economic environment of the construction industry necessitates the provision of tools to control the risk loads in construction companies (Girmscheid 2001), (Girmscheid and Busch 2005). This prompted ETH Zurich to develop the holistic, probabilistic Risk Management Process Model (RMPM) in collaboration with the Swiss Association of General Constructors (Girmscheid 2001).

Based on the risk load aggregation (bottom-up approach) from projects up to company level (Girmscheid 2001) this publication discusses the risk resistance capacity dimension (top-down approach) with its structured risk coverage resources and resistance capacity limits of the Risk Management Process Model (RMPM). In addition the risk load resistance theorem constitutes the risk process control dimension (integrative approach) (Fig. 1).

Keywords: Construction Company Management, Risk Management, Risk Coverage, Risk Resistance Capacity Limits, Risk Resistance Theorem

1. INTRODUCTION
The risk load dimension (bottom-up approach) was presented as the first of a total of three RMPM dimensions in a previous publication (Girmscheid 2006) for project-oriented construction enterprises. This risk load dimension address various load scenarios and aggregates the risk loads at different corporate levels. This publication now builds on the first dimension to present the last two dimensions of RMPM (Fig. 1):

- Risk resistance capacity dimension - "top-down" approach
Risk process control dimension - integrative approach

![Diagram of Holistic, Probabilistic Enterprise Risk Management Process Model](image)

**Figure 1** Structure of the holistic, probabilistic Risk Management Process Model (RMMP) for project-oriented Enterprises (the content of this paper is color-marked)

The risk resistance capacity dimension - a top-down approach – structures the monetary resources available to cover risks in order to determine and specify the risk resistance capacity using a top-down approach. The other dimension is that of risk process control - an integrative approach - that focuses on three control concepts.

2. **STATE OF RESEARCH**

The state of risk management research was presented in (Markowitz 1991), (N.N. 2005), (Schierenbeck and Lister 2001), (Kremers 2002). Until now, a holistic probabilistic Risk Management Process Model is neither available in practice nor in research to aggregate the contractually agreed project risks at the various corporate levels to define the risk load and to derive the risk resistance capacity of a company based on its financial and asset-related resources according to insolvency/bankruptcy theory.
3. RESEARCH METHODOLOGY

The constructivist research paradigm according to Guba and Lincoln (1994) and Girmscheid (2004) is used to structure both the bottom-up approach for risk aggregation and the risk load theorem, and the top-down approach to determine the risk resistance capacity, and to merge them into the RMPM (integrative approach). This constructivist Risk Management Process Model is validated by triangulation (Yin 2002) using a theoretical framework and realization tests (Girmscheid 2004). The model (Stachowiak 1989) was structured using system theory (v. Bertalanffy 1968), (Boulding 1956) and financial (Ross, Westerfield and Jaffe 1993) and mathematical theories.

4. RISK RESISTANCE CAPACITY DIMENSIONS – top-down APPROACH

4.1 RISK COVERAGE RESOURCES

The risk coverage resources of an enterprise are comprised of the financial or asset-related resources as defined by financial enterprise theory (Ross, Westerfield and Jaffe 1993). To prevent an enterprise from legal bankruptcy, which can be caused by a failed financial restructuring, the following two conditions of insolvency have to be met at all times.

The cash flow dimension is linked to the flow-based insolvency theory which is related to the dynamic cash flow. The following cash flow condition has to be met to prevent a flow-based insolvency (cash-flow insolvency):

\[ \Delta C \geq 0 \]  \hspace{1cm} (1)

with:
\[ \Delta C = CF(A) - RP = CF(A) - (CF(B) + CF(S)) \]

The flow-based insolvency is defined by:

\[ \Delta C < 0 \]  \hspace{1cm} (2)

with:
\[ \Delta C = \text{solvency balance (surplus of cash flow/surplus of liquid assets)} \]
\[ CF(A) = \text{firm/operating cash flow (liquid asset)} \]
\[ RP = \text{required payments} \]
\[ CF(B) = \text{cash flow to the firm’s creditors} \]
\[ CF(S) = \text{cash flow to the firm’s equity investors} \]

The asset/profit dimension is linked to stock-based insolvency theory, with is related to the assets and liabilities. These assets and liabilities are reported in the balance sheet and the profit and loss (income) statement.

The following asset and liability condition must be met to prevent possible stock-based insolvency:

\[ A \geq L \]  \hspace{1cm} (3)

with:
\[ A = \text{total value of assets} \]
\[ L = \text{total value of liabilities (debts)} \]
The stock-based insolvency (overindebtedness) is defined by:

\[ CA + FA < CL + LTL \]  

with: (classification of assets and liabilities)

\[ \begin{align*}
    CA & = \text{current assets} \\
    FA & = \text{fixed assets} \\
    CL & = \text{current liabilities (short term debts)} \\
    LTL & = \text{long term liabilities (debts)}
\end{align*} \]

In the cash flow risk model and asset/profit risk model, the risk resistance capacity limits of enterprises are differentiated into three risk coverage resource classes according to the structured risk load limits as follows:

- Normal risk coverage class – 1st class
- Stress risk coverage class – 2nd class
- Crash risk coverage class – 3rd class

These three classes of risk coverage resources constituting the risk resistance capacity limits are related to:

- Flow-based insolvency – cash flow related risk coverage
- Stock-based insolvency – balance sheet related risk coverage

The first class of cash flow and asset risk coverage resources \( RCR_{F1} \) and \( RCR_{A1} \) is designed to be covered from daily operating revenues for risk occurring quite often with a probability of occurrence \((1-\alpha)\) of: \(40\% \leq (1-\alpha) \leq (1-\alpha_{\text{aik}})\). The second class of cash flow and asset risk coverage resources \( RCR_{F2} \) and \( RCR_{A2} \) is designed to cover risks which have a probability of quite rare occurrence \((1-\alpha)\) of: \(10\% \leq (1-\alpha) \leq 40\%\). The third class of cash flow and asset risk coverage resources \( RCR_{F3} \) and \( RCR_{A3} \) is designed to cover risks which have a probability of very rare occurrence \((1-\alpha)\) of: \(1\% \leq (1-\alpha) \leq 10\%\).

The cash flow and asset-related risk coverage resources were assigned to the three risk coverage classes in line with their temporal availability.

### 4.2 RISK RESISTANCE CAPACITY LIMITS

The three risk resistance capacity limits, which will be compared to the risk load limits, can be derived from the three escalating risk load coverage classes. The three risk resistance capacity limits form the resistance barriers of the enterprise in relation to the severity of the risk load impact. The three risk resistance capacity limits are defined as follows:

- Normal risk resistance capacity limit \( RRC_{N,j} \)
- Stress risk resistance capacity limit \( RRC_{S,j} \)
- Crash risk resistance capacity limit \( RRC_{C,j} \)
The entrepreneurial risk coverage resources RCR of the three different classes for defining the risk resistance capacity limits consist of cash flow and asset resources and are represented by the risk coverage resource matrix (RCR):

\[
(\text{RCR}) = \begin{pmatrix}
RCR_{F1} & RCR_{F2} & RCR_{F3} \\
RCR_{A1} & RCR_{A2} & RCR_{A3}
\end{pmatrix}
\] (5)

Risk coverage resources RCR are allocated to the various risk load limit states using the following risk resistance capacity (RRC) matrix:

\[
\{\text{RRC}\}_{\text{total}} = \{(\text{RRC}_{Nm});(\text{RRC}_{Sm});(\text{RRC}_{Cm})\}
\]

\[
m = (F; A)
\]

Risk resistance capacity matrix with assigned risk coverage resources:

\[
(\text{RRC})_{n=\text{NSC}} = \begin{pmatrix}
RCR_{F1} \\
RCR_{A1}
\end{pmatrix}_N, \begin{pmatrix}
RCR_{F1} + RCR_{F2} \\
RCR_{A1} + RCR_{A2}
\end{pmatrix}_S, \begin{pmatrix}
RCR_{F1} + RCR_{F2} + RCR_{F3} \\
RCR_{A1} + RCR_{A2} + RCR_{A3}
\end{pmatrix}_C
\]

\[
\text{Cash flow / financial}
\]
\[
A \text{ Assets/profits}
\]
\[
N \text{ Normal risk resistance capacity limit}
\]
\[
S \text{ Stress risk resistance capacity limit}
\]
\[
C \text{ Crash risk resistance capacity limit}
\]

The principle of minimal risk resistance capacity:

\[
(\text{RRC})_{n=\text{NSC}}^{\text{min}} = \text{Min}\{(\text{RRC})_{F,n};(\text{RRC})_{A,n}\}_{n=\text{NSC}}
\]

\[
= \text{Min}\left\{ \begin{pmatrix}
RRC_{FN} \\
RRC_{FS} \\
RRC_{FC}
\end{pmatrix}, \begin{pmatrix}
RRC_{AN} \\
RRC_{AS} \\
RRC_{AC}
\end{pmatrix} \right\}
\]

\[
= \text{Min}\left\{ \begin{pmatrix}
RCR_{F1} \\
RCR_{A1}
\end{pmatrix}, \begin{pmatrix}
RCR_{F1} + RCR_{F2} \\
RCR_{A1} + RCR_{A2}
\end{pmatrix}, \begin{pmatrix}
RCR_{F1} + RCR_{F2} + RCR_{F3} \\
RCR_{A1} + RCR_{A2} + RCR_{A3}
\end{pmatrix} \right\}
\]

The decisive risk resistance capacity limit is derived from the principle of minimal risk coverage resources at various load limits due to the invariance of load theorem (Fig. 2):
4.3 DISTRIBUTION OF RISK COVERAGE RESOURCES

The total risk coverage resources of an entire enterprise have to be distributed to the various strategic business units (SBUs). The SBUs are subjected to different degrees of risk loads, depending on their field of business. This risk load is not linear for the SBU and is dependent on turnover, the type and size of project, and other factors.

The average risk coverage resources (RCR) per Dollar turnover can be expressed by the unit risk coverage coefficient matrix:

\[
(r_c) = \begin{bmatrix} (r_{c_F})^T \\ (r_{c_A})^T \end{bmatrix}_{c_l = 1, 2, 3}
\]

\[
= \frac{1}{U_{\text{total}}} (RCR)_{c_l = 1, 2, 3} = \frac{1}{U_{\text{total}}} \begin{bmatrix} RCR_{F_1} & RCR_{F_2} & RCR_{F_3} \\ RCR_{A_1} & RCR_{A_2} & RCR_{A_3} \end{bmatrix}
\]

\[
= \begin{bmatrix} r_{c_{F_1}} & r_{c_{F_2}} & r_{c_{F_3}} \\ r_{c_{A_1}} & r_{c_{A_2}} & r_{c_{A_3}} \end{bmatrix}
\]

c_l \quad \text{coverage classes; } i = \{1; 2; 3\}

r_{c_{m,i}} \quad \text{average risk coverage unit per dollar turnover and risk load coverage class}

---

**Figure 2** Cash flow risk function of CRM - Risk load limits for the cash flow risk resistance capacity
Average unit risk resistance capacity coefficient matrix:

\[
(rr)_{n=NSC} = \begin{bmatrix}
(rr_F)^T \\
(rr_A)^T
\end{bmatrix}
\]

\[
= \frac{1}{U_{total}} (RRC)_{n=NSC} = \frac{1}{U_{total}} \begin{bmatrix}
RRC_{FN} & RRC_{FS} & RRC_{FC} \\
RRC_{AN} & RRC_{AS} & RRC_{AC}
\end{bmatrix}
\]

\[
rr_{m,n} \quad \text{average risk resistance capacity unit per dollar turnover}
\]

\[
m = (F; A)
\]

\[
n = \{NSC\} \quad \text{risk resistance capacity limits}
\]

5. RISK PROCESS CONTROL DIMENSION

The risk process control dimension uses an integrative approach to pursue three control concepts:

- Risk load resistance theorem
- Calculation of opportunities-threats
- Redistribution concept of risk coverage resources

The risk load resistance theorem enables the adjustment of the potential risk load at any company level according to the risk resistance capacity of the company as a whole (Fig. 3). The risk resistance capacity is limited in both financially oriented and asset oriented terms by the allocated risk coverage resources. Each business unit and the overall company have to ensure that the potential risk load is always smaller than the risk resistance capacity.

The calculation of opportunities-threats applies the risk reward ratio (RoRaC) to determine the efficient use of the risk coverage resources assigned to a project, a branch office or a strategic business unit. In order to optimize the opportunities-threats potential, this efficiency coefficient can be used to reallocate or redistribute the risk limits among the various corporate divisions within an enterprise using the redistribution concept of risk coverage resources. The latter two control concepts are not part of this publication (Girmscheid and Busch 2005).

5.1 RISK LOAD RESISTANCE THEOREM

The risk load must not exceed the risk resistance capacity limits at any level of the enterprise (Fig. 3).
This is expressed by the risk load resistance theorem as follows:

Risk load dimension ≤ minimum Risk resistance capacity limits in dependency of risk coverage resources

\[
\begin{align*}
(VaR)_{n=NSC} & \leq (RRC_{\text{min}})_{n=NSC} \\
\{VaR_N\} & \leq \{RRC_{N,\text{min}}\} = \{RRC_N = \{RRC_{N}\} = \text{Min}\{RRC_{FN, N}\}\} \\
\{VaR_S\} & \leq \{RRC_{S,\text{min}}\} = \{RRC_S = \{RRC_{S}\} = \text{Min}\{RRC_{FS, S}\}\} \\
\{VaR_C\} & \leq \{RRC_{C,\text{min}}\} = \{RRC_C = \{RRC_{C}\} = \text{Min}\{RRC_{FC, C}\}\}
\end{align*}
\]  

(10)

The risk load dimension is expressed by the value at risk (VaR) through the invariance of cash flow at risk (CFaR) and earnings at risk (EaR) (Girmscheid 2006).

\[
(VaR)_{n=NSC} = (CFaR)_{n=NSC} = (EaR)_{n=NSC} = \text{invariant}
\]  

(11)

The risk resistance capacity limits result from the minimal condition of financial and asset resources as follows:

\[
(RRC_{\text{min}})_{n=NSC} = \text{Min}\{RRC_{F,n}^T n=NSC; RRC_{A,n}^T n=NSC\}
\]  

(12)
6. CONCLUSION

The holistic probabilistic RMPM is a process tool that enables companies to consciously consider risk in order to maximize profit. The implementation of the holistic probabilistic RMPM offers the following benefits:

- It generates risk awareness at all levels of an enterprise
- It ensures the efficient use of company resources
- Target oriented enterprise development

The holistic probabilistic RMPM provides project-oriented enterprises with a holistic risk tool that quantifies the risk load at all levels of an enterprise and compares the risk load with the existing risk coverage resources available both at present and forecast for the future.

7 LITERATURE

Girmscheid, G. and Busch, T., 2005, Ganzheitliches Risikomanagement in Generalunternehmungen. Institut für Bauplanung und Baubetrieb, ETH Zürich, 2005
Girmscheid, G. (2004): Forschungsmethodik in den Baubetriebswissenschaften. Eigenverlag des IBB an der ETH Zürich, Zürich, 2004