Optimization of Integrated Risk in Commercial Banking Based on Financial Statements

Chunbing Bao\textsuperscript{a, b}, Jianping Li\textsuperscript{a,*}, Dengsheng Wu\textsuperscript{a}, Xiaoqian Zhu\textsuperscript{a, b}, Changzhi Liang\textsuperscript{a, b}, Chang Liu\textsuperscript{a, b}

\textsuperscript{a}Institute of Policy & Management, Chinese Academy of Sciences, Beijing 100190, China
\textsuperscript{b}University of Chinese Academy of Sciences, Beijing 100049, China

Abstract

Integrated risk control and asset optimization is an important issue in commercial bank industry. This paper combines balance sheet with income statement, and forms a structure measuring each asset’s risk based on the method using income statement only, having a better use of the data resource. Considering the commercial bank’s diversified pursuit of low risk and high profit, we solve the problem using the method of multiple objective programming, and we give the Pareto surface to support selection decisions. The analysis framework of the integrated risk optimization based on financial statements provides a feasible idea for commercial banks’ asset optimization research with limited data resource.

© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/3.0/).
Selection and peer-review under responsibility of the Organizing Committee of ITQM 2014.

Keywords: commercial banks; integrated risk; financial statements; multi-objective programming; asset optimization

* Corresponding author. Tel.: 86-10-59358805
E-mail address: ljp@casipm.ac.cn
1. Introduction

Currently, commercial banks gradually show a trend of diversification and their financial services are becoming wider and wider, for example, deposit and loan business, for settlement services, issuing financial bonds, government bond trading business, and so on. The diversification will lead to more different risks. According to Basel II, the main risks faced by commercial banks are market risk, credit risk and operational risk. Rosenberg and Schuermann find that given a risk type, total risk is more sensitive to differences in business mix or risk weights. As a result, a rational method to control risks is asset optimization. We attempt to reset and allocate the assets faced by different risks in order to decrease commercial banks’ integrated risk.

So far, many theories have been proposed for asset optimization. Schlottmann considers that different combinations of assets will have different effects on various types of risks. Through establishing objective functions of different risk assets, he solves the problem of asset optimization by multi-objective programming approach. But his model lacks of risk integration, and ignores profit is also the factor commercial banks pursues; Calafiore considers the multi-stage sequential decision-making process in order to reduce the cumulative risk to make multi-stage optimizations of assets which meet revenue targets. But the paper lacks of maneuverability; Kosmidou and Zopounidis help commercial banks manage their interest rate risk by simulation analysis with objective programming approach, but they doesn’t make an analysis to other risks; Gerstner and Griebel propose the use of deterministic integration schemes, such as quasi-Monte Carlo and sparse grid quadrature methods for stochastic asset-liability management models; Chiu and Li embed risk-minimizing target into dynamic asset management, and find that the optimal trading strategy is on the mean-variance border, but they doesn’t make any restrictions on revenue; Ferstl and Weissensteiner consider a multi-stage setting under time-varying investment opportunities and propose a decomposition of the benefits in dynamic re-allocation and predictability effects. This method also doesn’t consider the restrictions on revenue. Chen and Yang consider an optimal portfolio selection problem under Markowitz’s mean-variance portfolio selection problem in a multi-period regime-switching model; Gülpinar and Pachamanova present an asset liability management model based on robust optimization techniques.

As shown in the scholars’ work, currently an important problem is the lack of reliable data which is the base of empirical research. For example, the internal rating based (IRB) approach for credit risk assessment proposes high data requirements. Due to the lack of other reliable sources, scholars attempt to obtain favorable information from published financial statements. Kuritzkes and Schuermann analyze market risk, credit risk, operational risk, business risk and asset-liability risk by establishing correspondence between the profit and loss accounts of income statement and risks for the major U.S. banks; Kretzschmar et al. construct a hypothetical bank using 51 European banks’ assets data in 2006. They get the risk-driven factors by classifying the assets, and simulate changes of the value of assets by Economic Scenario Generation model (ESG) and finally access the distribution of bank assets and calculate the overall risk; Li et al. get data by establishing correspondence between risks and profit and loss accounts of Chinese major securities firms. The changes of pre-tax profits represent the overall risk according to them. And they analyze the dispersion effect of risks by simple addition of all the risks. From the studies, the current common practice is to use the income statement data, but in fact there are balance sheet, cash flow statement and other information. And also in theory, combining balance sheet with other information might more accurately reflect the risk of assets. Li et al. mainly consider establishing correspondence between single risk and income statement, but it can’t reflect the correspondence between the assets and risks merely using the income statement.

Besides, asset optimization studies are always accompanied by a number of objectives like risk, revenue, etc. which are also consistent with the actual situation. In summary, how to use publicly available data to establish the correspondence between the assets and risks and how to use multi-objective programming to optimize are the problems this paper will solve.

2. Risk measuring structure based on financial statements

Li et al. establish the correspondence between gains and losses accounts like the net interest income and market risk using the financial statements. And they measure individual risks through the VaR method by using public financial data. But the above process can’t establish a correspondence between assets and risks. Therefore, we should re-interpret the balance sheet and make a new classification of the assets.
Through the analysis of the assets and liabilities of balance sheet, we find that for the particular industry commercial banks, their assets and liabilities are mainly deposits and loans, and therefore their incomes and expenditures must be derived from deposits and loans. In fact, take balance sheet of Industrial and Commercial Bank of China’s in 2012 as an example, loans accounted for nearly 70% of total assets, and deposits reached 80% of the liabilities. On the other hand, in the income statement, interest revenue accounted for 80% of total revenue. Therefore, we attempt to make a new division of assets and liabilities based on interest which is the main part in commercial banks. The general idea is to divide the income into interest income and non-interest income and divide total assets into interest-earning assets, interest-bearing liabilities and other assets and liabilities.

Interest-earning assets include loans and advances to customers, investment, non-restructuring bonds, restructuring bonds, deposits in the central bank, storage and lending of banks and other financial institutions; Interest-bearing liabilities mainly include deposits, bonds issued and other banks and other financial institutions’ deposits and borrowed money.

Profit and loss accounts irrelevant to interest are fee and commission income, investment income, changes in fair value of net profit and loss, net gains and losses from foreign exchange and foreign exchange products, other business net income and net non-operating income.

On the correspondence between the assets and outside accounts of net interest income, the paper makes the following assumptions:

Fee and commission income mainly includes financial consultation fees, credit commitment fees, commitment fees and other guarantees. We consider that they are related to size of overall assets, thus we assume these fees are relevant to the total assets.

Investment income mainly refers to investment in non-interest-earning assets, including held-to-maturity investments, receivables investments, and securities investments like long-term equity investments.

Changes in the fair value of net profit or loss are the profit or loss due to changes in fair value, for example, the stock price’s changes. Since it corresponds to many assets, we name the assets relevant to it as FVTPL.

Net gains and losses from foreign exchange and foreign exchange products are contain the gains and losses related to exchange rate and therefore, we name the related assets as exchange rate assets.

Other business net income and net non-operating income are considered as relevant to the overall size of the bank. Therefore, the related assets to these accounts are total assets.

Now, we can build one to one relationships among profits and loss, assets and risks as follows:

\[
\begin{align*}
\text{Net interest income} & \quad \rightarrow \quad \text{Interest bearing assets} \\
+ \text{Fee and commission income} & \quad \rightarrow \quad \text{Total assets} \\
+ \text{Net gains from foreign exchange} & \quad \rightarrow \quad \text{Exchange rate assets} \\
+ \text{Changes in fair value of} & \quad \rightarrow \quad \text{FVTPL} \\
\text{net profits and losses} & \quad \rightarrow \quad \text{Investment assets} \\
+ \text{Net investment profit} & \quad \rightarrow \quad \text{without interest} \\
- \text{Loan impairment} & \quad \rightarrow \quad \text{Loan impairment} \\
- \text{Other asset impairment losses} & \quad \rightarrow \quad \text{Other assets except} \\
\text{loan impairment} & \quad \rightarrow \quad \text{Total assets} \\
- \text{Business and management costs} & \quad \rightarrow \quad \text{Total assets} \\
+ \text{Other business net income} & \quad \rightarrow \quad \text{Total assets} \\
+ \text{net non-operating income} & \quad \rightarrow \quad \text{Total assets} \\
\end{align*}
\]

= Pre-tax profit

Fig. 1. Corresponding relationships among income accounts, assets and risks
3. Optimization model based on multi-objective programming

3.1. Objective Functions

We are desirable to establish a linear integrated model of risk. Although there are differences among simple summation, variance–covariance and copula approach, the purpose of this paper is to minimize asset portfolio’s overall risk rather than getting a specific overall risk. Thus simple linear addition will reflect the changes of risks. Therefore, this paper gives the following expression for integrated risk:

\[ \text{Risk}(X) = \sum R_i(X) \]

where \( X = (x_{a1}, x_{a2}, \ldots, x_{an}, x_{d1}, x_{d2}, \ldots, x_{dm}) \) denotes asset liability portfolio, \( R_i(X) \) denotes the \( i^{th} \) risk.

For a specific risk \( R_i(X) \), we hope to give linear expression on the portfolio:

\[ R_i(X) = \sum r_{ij}x_{aj} \]

where \( r_{ij} \) represents the \( i^{th} \) risk of asset \( j \), and in this paper it specifically refers to VaR which we consider as the risk of asset per unit; \( x_{aj} \) denotes size of the \( j^{th} \) asset. Therefore, we measure the total risk by the total assets’ gross VaR.

In addition, profit function is defined as the difference between profit and loss of the assets and liabilities:

\[ \text{ret}(X) = \sum x_{aj}p_{aj} - \sum x_{dj}p_{dj} \]

where \( p_{aj} \) and \( p_{dj} \) denote profit or loss of the \( j^{th} \) asset or liability.

3.2. Constraints

After forming the integrated risk, we will consider the constraints of assets or liabilities next.

- Capital adequacy ratio constraint. Our CBRC requires that each bank or banking group should maintain the ratio of total regulatory capital to risk-weighted assets more than 12%. So, we have the following expression:

\[ \frac{\text{Capital}}{\text{RWA}} \geq 12\% \] (1)

where, \( \text{RWA} \) represents risk-weighted assets.

- The deposit reserve constraint. Under the law of the Central Bank, commercial banks should deposit a certain percentage of their gathered deposits to the People’s Bank in order to control banks’ lending. The proportion of the deposit is usually determined by the central bank, known as the deposit reserve ratio. According to the law of our country, from May 18, 2012, the deposit reserve ratio of large financial institutions is not less than 20%. Therefore, we have:

\[ x_c \geq 20\% \times \sum x_{dj} \] (2)

where, \( x_c \) represents deposits in central banks, \( \sum x_{dj} \) represents banks’ gathered deposits (liabilities).

- The constraint of deposits. The source of most of the assets of the bank is deposits (liabilities) they absorbed. Banks have to absorb more deposits to lend out more money. But according to the actual situation, we think
there is an upper border. So, we have:

\[ a \leq \sum x_{ij} \leq b \]  

(3)

where, \( a \) and \( b \) represent the borders of deposits.

- **Loans constraint.** According to laws, banks’ loans cannot exceed 75% of the deposits, which means the constraints of deposits will lead to constraints of loans. So, we have:

\[ c \leq \sum x_{ij} \leq d \]  

(4)

where, \( c \) and \( d \) represent the borders of loans.

- **Cash scale constraint.** In order to meet the needs of customers’ withdrawal and cash flow for emergencies, we require that a certain proportion of the total assets of the bank should be maintained. So, we have:

\[ \alpha_1 \sum x_{ij} \leq x_{cash} \leq \alpha_2 \sum x_{ij} \]  

(5)

where, \( x_{cash} \) represents the amount of cash, \( \sum x_{ij} \) represents the sum of assets and \( \alpha_1 \) and \( \alpha_2 \) represent the corresponding ratios.

It should be noted that the above constraints only lists some of the common conditions, other conditions related to assets of commercial banks can be added in the future studies.

3.3. Multi-objective programming model

So far, the multi-objective programming model of this paper has been set up as follows:

\[
\begin{align*}
\text{Max} & \quad \left\{ \begin{array}{l}
\text{ret}(X) = \sum x_{ij} p_{ij} - \sum x_{ij} p_{ij} \\
-Risk(X) = -\sum \sum z_{ij}\end{array} \right. \\
\text{s.t.} & \quad \begin{array}{l}
\frac{\text{Capital}}{\text{RWA}} \geq 12\% \\
x_i \geq 20\% \times \sum x_{ij} \\
\sum x_{ij} \leq \sum x_{ij} \leq b \\
c \leq \sum x_{ij} \leq d \\
\alpha_1 \sum x_{ij} \leq x_{cash} \leq \alpha_2 \sum x_{ij}
\end{array}
\end{align*}
\]  

(6)

4. Empirical Study of Asset Optimization of China’s listed commercial banks

Taking ICBC’s financial statements in 2012 as an example, we can find that net interest income accounted for nearly 80% of the entire revenue, while interest-earning assets accounted for 95.7% of total assets. Therefore, this paper will only consider interest-earning assets and interest-bearing liabilities in the model.

4.1. Data sources and data pre-processing

All data sources are from the financial reports of commercial banks, including income statement, balance sheet and detailed analysis, supplement of financial reports.
In this empirical study, we use financial data of 14 banks from 2007 to 2012, which are Beijing Bank, Industrial and Commercial Bank of China (ICBC), China Everbright Bank(CEB), Hua Xia Bank(HXB), China Construction Bank(CCB), Bank of Communications(BOCM), China Minsheng Banking Corp.Ltd.(CMBC), Bank of Nanjing(BNJ), Shanghai Pudong Development Bank(SPDB), Shenzhen Development Bank(SDB), Industrial Bank(CIB), China Merchants Bank(CMBC), Bank of China(BOC) and China CITIC Bank. We get 168 groups of data published half a year.

This paper divides interest-earning assets and interest-bearing liabilities in more details. Loans and advances to customers are subdivided into corporate loans, bill discount, personal loans, overseas and other business. Investment is divided into non restructuring bonds and restructuring bonds. And deposit is divided into the corporate and personal deposits and overseas and other businesses.

First, the data is normalized to avoid the influence of different sizes in different banks in assets:

\[ r_{ijt} = \frac{R_{ijt}}{A_{ijt}} \]

where \( R_{ijt} \) and \( r_{ijt} \) represent revenue and rate of return of the \( j^{th} \) risk of the \( i^{th} \) bank within period \( t \) and \( A_{ijt} \) represents the correspond risk-weighted assets.

According to the above method, we get each asset’s yield rate (Table 1):

### Table 1. Each asset’s initial value and yield rate or interest rate of ICBC in 2012

<table>
<thead>
<tr>
<th>Assets</th>
<th>Symbol</th>
<th>Initial Value</th>
<th>Yield rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>( x_1 )</td>
<td>1,201,647</td>
<td></td>
</tr>
<tr>
<td>Deposit in the central bank</td>
<td>( x_2 )</td>
<td>1,973,296</td>
<td>1.62%</td>
</tr>
<tr>
<td>Corporate loans</td>
<td>( x_3 )</td>
<td>5,618,165</td>
<td>6.02%</td>
</tr>
<tr>
<td>Bill discount</td>
<td>( x_4 )</td>
<td>192,354</td>
<td>6.11%</td>
</tr>
<tr>
<td>Personal loans</td>
<td>( x_5 )</td>
<td>2,099,358</td>
<td>5.59%</td>
</tr>
<tr>
<td>Overseas and other business</td>
<td>( x_6 )</td>
<td>476,654</td>
<td>3.54%</td>
</tr>
<tr>
<td>Non restructuring bonds</td>
<td>( x_7 )</td>
<td>3,488,859</td>
<td>3.44%</td>
</tr>
<tr>
<td>Restructuring bonds</td>
<td>( x_8 )</td>
<td>350,636</td>
<td>2.21%</td>
</tr>
<tr>
<td>Storage and lending of banks and other financial institutions</td>
<td>( x_9 )</td>
<td>853,392</td>
<td>2.64%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liabilities</th>
<th>Symbol</th>
<th>Initial Value</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate deposit</td>
<td>( y_1 )</td>
<td>6,111,240</td>
<td>1.48%</td>
</tr>
<tr>
<td>Personal deposit</td>
<td>( y_2 )</td>
<td>6,072,465</td>
<td>1.93%</td>
</tr>
<tr>
<td>Overseas business</td>
<td>( y_3 )</td>
<td>326,138</td>
<td>1.67%</td>
</tr>
<tr>
<td>Other banks and other financial institutions’ deposits and borrowed money</td>
<td>( y_4 )</td>
<td>1,694,972</td>
<td>1.75%</td>
</tr>
<tr>
<td>Bonds issued</td>
<td>( y_5 )</td>
<td>264,493</td>
<td>3.51%</td>
</tr>
</tbody>
</table>

The quantity of total assets is 13.26 million and the quantity of total liabilities is 14.47 million.

### 4.2. Parameter setting

This paper mainly considers the market risk of commercial banks from net interest income. For discrete data, according to the definition of VaR, we take a confidence level of 99%, and the \((168 \times 1\%) = 17^{th}\) number is the VaR re-sorting the data in ascending order, which means the probability that risk is greater than \(\text{VaR}_{99\%}\) (or the yield rate is less than \(\text{VaR}_{99\%}\)) is 1%.
With this method, we get the market risk of each asset (table 2):

<table>
<thead>
<tr>
<th>Assets</th>
<th>Symbol</th>
<th>Market risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>$x_1$</td>
<td></td>
</tr>
<tr>
<td>Deposit in the central bank</td>
<td>$x_2$</td>
<td>0.0053</td>
</tr>
<tr>
<td>Corporate loans</td>
<td>$x_3$</td>
<td>0.0152</td>
</tr>
<tr>
<td>Bill discount</td>
<td>$x_4$</td>
<td>0.0283</td>
</tr>
<tr>
<td>Personal loans</td>
<td>$x_5$</td>
<td>0.0365</td>
</tr>
<tr>
<td>Overseas and other business</td>
<td>$x_6$</td>
<td>0.0093</td>
</tr>
<tr>
<td>Non restructuring bonds</td>
<td>$x_7$</td>
<td>0.0068</td>
</tr>
<tr>
<td>Restructuring bonds</td>
<td>$x_8$</td>
<td>0.0162</td>
</tr>
<tr>
<td>Storage and lending of banks and other financial institutions</td>
<td>$x_9$</td>
<td>0.0098</td>
</tr>
</tbody>
</table>

Liquidity risk resulting from net investment income is 0.000495. We assume that banks consider all their assets and liabilities before investing, thus each asset (from $x_1$ to $x_9$) will have the liquidity risk of 0.000495.

In addition, the credit risk is 0.02317 which is got by similar VaR method with loan impairment divided by risk-weighted assets. As loan impairment corresponds to loans which refer to corporate loans, bills discounting, personal loans, and overseas and other businesses, we consider that credit risk exists in corporate loans, bills discounting, personal loans, and foreign and other businesses (from $x_3$ to $x_6$).

At last, we think that operational risk is the rest of the overall risk except the 3 kinds of risks which is 0.01859. And we consider it exists in all the assets from $x_3$ to $x_9$.

Besides, constrains are set as follows:

- The first constraint is capital adequacy ratio. The total capital of ICBC in 2012 was 1,299,014. According to Rules for Regulating the Capital Adequacy Requirement of Commercial Banks, we consider that risk weight is 0 for $x_1$ and $x_2$, 20% for $x_9$, 50% for $x_3$, $x_7$ and $x_8$ and 100% for $x_4$ to $x_6$. So risk-weighted assets are:

\[
0.2x_9 + 0.5x_3 + 0.5x_7 + 0.5x_8 + x_4 + x_5 + x_6
\]

In addition, we only select 7.7 million risk-weighted assets which account for 80.7% of the total. Therefore, constrained capital adequacy ratio can be described as follows:

\[
1.3\times 0.807/(0.2x_9 + 0.5x_3 + 0.5x_7 + 0.5x_8 + x_4 + x_5 + x_6) \geq 12\%
\]  \hspace{1cm} (7)

- The current reserve requirement ratio is 20%, therefore the reserve constraint is:

\[
x_2 \geq 20\%(y_1 + y_2 + y_3 + y_4 + y_5)
\]  \hspace{1cm} (8)

- In this paper, we give a upper border to deposits:

\[
12.5 \leq y_1 + y_2 + y_3 \leq 12.5 \times 1.3 = 16.25
\]  \hspace{1cm} (9)

where 12.5 is the amount of the initial deposits.

- Also, there is a limit to the growth of loans:

\[
8.39 \leq x_1 + x_4 + x_5 + x_6 \leq 8.39 \times 1.3 = 10.907
\]  \hspace{1cm} (10)
where 8.39 is the amount of the initial loans.

Finally, we requires that cash scale is between 5% and 10% of total assets:

\[ x_t \leq 0.1(x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9) \quad (11) \]

\[ x_t \geq 0.05(x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9) \quad (12) \]

### 4.3. Model multi-objective optimization model

Through the above analysis, we obtain the following multi-objective optimization model:

\[
\begin{align*}
\text{ret}(X) &= 1.62\%x_2 + 6.02\%x_3 + 6.11\%x_4 + 5.59\%x_5 + 3.54\%x_6 + 3.44\%x_7 + \\
&\quad 2.21\%x_8 + 2.64\%x_9 - 1.48\%y_1 - 1.93\%y_2 - 1.67\%y_3 - 1.75\%y_4 - 3.51\%y_5 \\
\text{Risk}(X) &= -(0.0053x_2 + (0.00152 + 0.00495 + 0.02317 + 0.01859)x_3 + \\
&\quad (0.0283 + 0.000495 + 0.02317 + 0.01859)x_4 + (0.0365 + 0.000495 + \\
\text{Max} &= (0.02317 + 0.01859)x_5 + (0.0093 + 0.000495 + 0.02317 + 0.01859)x_6 + \\
&\quad (0.0068 + 0.000495 + 0.01859)x_7 + (0.0162 + 0.000495 + 0.01859)x_8 + \\
&\quad (0.0098 + 0.000495 + 0.01859)x_9] \\
\quad = -(0.0053x_2 + 0.057455x_3 + 0.070555x_4 + 0.078755x_5 + 0.05155x_6 + \\
&\quad 0.025885x_7 + 0.035285x_8 + 0.028885x_9) \\
\end{align*}
\]

\[ 
\begin{align*}
\text{s.t.} & \quad 1.049/(0.2x_9 + 0.5x_4 + 0.5x_7 + 0.5x_4 + x_3 + x_6) \geq 12\% \\
& \quad x_2 \geq 20\%(y_1 + y_2 + y_3 + y_4 + y_5) \\
& \quad 12.5 \leq y_1 + y_2 + y_3 \leq 6.25 \\
& \quad 8.39 \leq x_3 + x_4 + x_5 \leq 10.907 \\
& \quad x_i \leq 0.1(x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9) \\
& \quad x_i \geq 0.05(x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9) \\
\end{align*}
\]

### 4.4. Results

The paper solves the multi-objective problem using MPSO algorithm with Matlab (version 2009a). The related parameter resigned as follows: \( T_{\text{max}} = 1000 \), \( w_{\text{max}} = 1000 \), \( w_{\text{min}} = 1000 \), \( c_1 = c_2 = 0 \) where \( T_{\text{max}} \) represents the maximum iterations, \( w_{\text{max}} \) represents the maximum inertia factor, \( w_{\text{min}} \) represents the minimum inertia factor, and \( c_1 \) and \( c_2 \) represent accelerated factors. Non-inferior solution set capacity is set to 100, the initial particle number is 200, and the non-inferior solution screening density is 0.05. Result of the algorithm is Pareto optimal solution set shown in Figure 2.
Figure 2 shows the Pareto surface, we can directly see the possible combinations of risk and profit under given constraint conditions. Besides, we can see from the figure that risk control target and profit target present linear displacement relationship and this relationship is different when profit changes. When profit is 0, the risk is nearly 0 and the risk increases as profit increases. In addition, the increasing speed of risk has the expanded tendency. The current situation of ICBC is presented in the figure as a dot which is not the best. For example, to maintain profit unchanged, we can adjust the asset portfolio to make the risk become smaller. And we will get the solution of the asset portfolio by single objective programming. After analyzing the solution, we can adjust the portfolio of asset to reduce the risk according to the changes of each asset’s value. For example, in order to reduce the risk, commercial banks should increase the proportion of storage in central bank so as to improve the ability to resist risk. Besides, they can increase the proportion of corporate loans and recombinant bonds and reduce the proportion of personal loans and so on. Similarly, to maintain risk unchanged, commercial banks can adjust their asset portfolio to make the profit become larger. This figure gives different risk control strategies under different profit. Decision makers can adopt different asset portfolios according to their preferences for risk and profit.

5. Conclusions

Based on the correspondence between profit and loss accounts and various types of risks based on commercial banks’ financial statements, this paper focuses on the re-division of assets in order to build the correspondence among assets, profit and loss accounts as well as different risks, providing a method to measure the risk of commercial banks’ assets. Besides, this paper introduces a multi-objective programming method and adds reasonable constraints, forming a Pareto optimal surface to optimize the portfolio of the assets of commercial banks to provide decision-making choices.

Judging from the division of assets, getting correspondence between assets and profit and loss accounts from the balance sheets of commercial banks seems difficult to make progress. We must look for other ways and accurately establish relations between assets and profit and loss accounts. And then, working out the assets’ risks and applying them to the model are the key points to solve the problem.

Moreover, according to the results of empirical analysis, there is an almost linear relationship between risk and profit. The higher the risk is the greater profit is. By analyzing Pareto optimal surface, commercial banks can compare the current situation with the optimal value and find the gap. Besides, the asset portfolio solved by the model can reflect the increase or decrease trend of the assets or liabilities serving the decision makers.
In the empirical study, we only consider the interest-earning assets and interest-bearing liabilities instead of the total of commercial banks. In addition, the integrated risk is expressed by a simple linear addition. More accurate forms of expression may be more conducive to the accuracy of the results. These are the stuffs that need to be improved.

Acknowledgements

This research is supported by National Nature Science Foundation of China (No. 71071148, No. 71003091), Key Research Program of Institute of Policy and Management, Chinese Academy of Sciences (Y201171Z05), the Youth Innovation Promotion Association of Chinese Academy of Sciences.

References

10. Kuritzkes A, Schuermann T. What we know, don't know and can't know about bank risks: A view from the trenches. *Wharton Financial Institutions Center working paper* No. 06-05, March 2006.