

An Information Model of Bank Loan Availability for Tech SMEs Based on System Dynamics

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Abstract. The bank loan availability refers to the bank loans financing ability of enterprises, which reflects the difficulty of obtaining bank loans. Because there are many factors that affect the bank loan availability of tech SMEs, and all factors affect each other, it is necessary to establish an information model to measure and predict the loan availability of tech SMEs. This paper constructs the loan availability model of tech SMEs by the idea of informatization and the theory of system dynamics. Firstly, the information processing is carried out on the credit policy of tech SMEs of general commercial banks. Determine credit rating and risk limit as the criteria to measure bank loan availability, and take this as the core to extract the factors affecting bank loan availability for tech SMEs. On this basis, the loan availability and its influencing factors are considered as a whole information system. By quantifying the logical quantitative relationship among the various factors in the system, a system dynamics information model of bank loan availability for tech SMEs is built. After reasonably configuring the simulation parameters of the model, the information model of bank loan availability for tech SMEs is simulated. In the end, test this information model. This information model can improve the information management level of tech SMEs, and help the tech SMEs to make financing strategies and development decisions.

Introduction

System Dynamics has an independent theoretical system and scientific method and is an important branch of system science. In 1968, the book "System Principles" published by Professor Jay W. Forrester comprehensively and systematically discussed the basic principles and application methods of system dynamics, marking the overall completion of system dynamics theory[1]. This paper introduces the theory of system dynamics into the SMEs' bank loan availability system, analyzes the causal relationship among various influencing factors, clarifies the positive and negative feedback loops affecting the loan availability system, and determines the functional expressions and various parameters between the influencing factors, builds a system dynamics information model of bank loan availability for tech SMEs, which is the combination of influencing factors from static to dynamic.

Analysis of Commercial Bank Loan Policy for Tech SMEs

Commercial banks currently do not have special policy preferences and lending methods for tech SMEs, and still mainly follow the credit policies and methods of ordinary SMEs. Although the evaluation methods of various banks are different, their core line is basically the same, which is to conduct credit rating of SMEs applying for loans first, and then determine the maximum amount of bank loans for SMEs according to the results of credit rating and the amount of assets of SMEs. As for the selection of factors affecting the credit rating, all banks are basically the same in the selection of key factors.

Credit Rating Method for SMEs. The decisive factor for commercial banks to lend to SMEs is the credit rating of SMEs. The credit rating is based on the cumulative score, and the score corresponding to each grade of SMEs are shown in Table 1.

Table 1 The score corresponding to each grade of SMEs

aaa	85 points or more
aa+	80 points (inclusive) ~ 85 points
aa	74 points (inclusive) ~ 80 points
aa-	68 points (inclusive) ~ 74 points
a+	62 points (inclusive) ~ 68 points
a	56 points (inclusive) ~ 62 points
a-	50 points (inclusive) ~ 56 points
b	44 points (inclusive) ~ 50 points
c	40 points (inclusive) ~ 44 points
d	40 points or less

The credit rating system for SMEs in commercial banks consists of three aspects: financial risk, qualitative evaluation and account behavior. There are also related secondary indicators and several tertiary indicators below each aspect. The final credit score of the SMEs is the result of adding all the three-level indicator scores multiplied by the corresponding weights.

Risk Limit Determining Method for SMEs. Commercial banks determine how much loans can be issued for SMEs based on risk limits. The risk limit refers to the maximum amount of credit granted by commercial banks in the future period based on the credit rating and repayment resources of SMEs.

1. Risk limit calculation formula:

$$\text{Risk limit} = \text{solvency base} \times \text{limit multiplier.} \quad (1)$$

The limit multiplier of SMEs with the same credit rating in different industries is also different. The solvency base is based on the sales revenue and net asset of SMEs.

2. Formula for calculating the solvency base:

$$\text{Solvency base} = \text{net asset} \times \text{net asset weight} + \text{sales revenue} \times \text{sales revenue weight.} \quad (2)$$

The weights corresponding to different industries are shown in Table 2.

Table 2 Solvency weights of various industries

industry	manufacturing	wholesale and retail	real estate	other
sales revenue weight	50%	70%	0%	50%
net asset weight	50%	30%	100%	50%
(sales revenue / net asset) the largest proportion	2.41	4.92	0	2.34

However, in view of the fact that tech SMEs generally belong to the manufacturing industry, the weight of net asset and sales revenue of SMEs can be determined by reference to manufacturing.

3. The limit multiplier is determined based on the credit rating of SMEs and their industries. In the same industry, the higher credit rating, the larger limit multiplier, and the greater risk limit determined by the limit multiplier. The possibility that the enterprise can obtain bank loans and the amount of loans will increase. The value of the customer limit multiplier in different industries is shown in Table 3.

Table 3 Limit multiplier in different industries

credit rating	manufacturing	wholesale and retail	real estate	other
aaa	1.2	1.13	0.85	1.2
aa+	1.1	0.8	0.7	1.1
aa	0.85	0.75	0.65	0.85
aa-	0.8	0.6	0.5	0.8
a+	0.55	0.5	0.4	0.55
a	0.35	0.3	0.2	0.35
a-	0.25	0.2	0	0.25
b	0	0	0	0
c	0	0	0	0
d	0	0	0	0

Dynamic Information Model Construction of Loan Availability System

Loan availability refers to the ease with which a funder can obtain a loan from a fund provider and the specific amount. In this paper, the measurement of the bank loan availability for tech SMEs is based on enterprise risk limit, supplemented by credit rating.

Determining the Loan Availability System Boundary. The system boundary of this research information model includes all the influencing factors that affect the credit rating and risk limit. Combined with the calculation formula of SMEs credit rating index system and risk limit of commercial bank, this paper determines the solvency base, limit multiplier, net asset, sales revenue, economic strength, quality, experience, operating capacity, sales revenue growth, tax situation, annual sales belong to bank, loan-to-deposit ratio, corporate debt service situation, economic environment, policy support, credit environment, industry ranking, product market, product technology, paid-in capital, asset-liability ratio, sales revenue/interest-bearing liability, paid-in capital/interest-bearing liability, and guarantee capacity are the boundaries of the bank loan availability system for tech SMEs.

Basic Assumptions of the Loan Availability Information Model. The following simplifications and assumptions are made in the process of establishing a bank loan availability simulation system information model for tech SMEs[2]:

1. Regardless of the time value of funds, changes in interest rates, and the effects of inflation;
2. Costs mainly consider production costs, labor costs, R&D investments and depreciation of fixed assets, regardless of other costs;
3. Simplify the processing of various products produced by the company and merge them into the same product;
4. Assume that the company invests in individuals and that the investment is stable during the simulation period;
5. Assume that corporate assets have only fixed assets and bank deposits, and interest-bearing liabilities are only bank loans;
6. The company has no foreign investment business;
7. The simulation duration is 50 years.

Structural Analysis of the Loan Availability System. According to the internal influencing factors of the bank loan availability system boundary identified above, with the most critical factor risk limit as the core, there are mainly six feedback loops: the risk limit increases, the interest-bearing liability increases, the net asset decreases, and the risk limit decreases, forming a negative feedback loop; the risk limit increases, the interest-bearing liability increases, the savings-loan ratio decreases, the credit rating decreases, the limit multiplier decreases, and the risk limit decreases, forming a negative feedback loop; the risk limit increases, the interest-bearing liability increases, the interest increases, the bank deposit decreases, the net asset decreases, the risk limit decreases, forming a

negative feedback loop; the risk limit increases, the interest-bearing liability increases, the interest increases, the bank deposit decreases, the fixed asset decreases, the net asset decreases, the risk limit decreases, forming a negative feedback loop; the risk limit increases, the interest-bearing liability increases, the interest increases, the bank deposit decreases, the fixed asset decreases, the credit rating decreases, the limit multiplier decreases, the risk limit decreases, forming a negative feedback loop; the risk limit increases, the interest-bearing liability increases, the interest increases, the bank deposit decreases, the loan-to-deposit ratio decreases, the credit rating decreases, the limit multiplier decreases, the risk limit decreases, forming a negative feedback loop. According to these complex causal relationships among these various indicators, the causal diagram of the loan availability system for tech SMEs can be obtained.

Establishment of the Loan Availability System Flow Diagram. In order to facilitate the discovery of the relationship between variables in the system, according to the scoring standard, this paper makes the following additions and adjustments to the factors in the system[3]:

1. Use personal total asset / paid-in capital to measure economic strength and introduce a new variable of economic strength index;
2. Introduce the industry experience index and management salary;
3. Introduce sales unit price, sales volume, market demand, sales revenue index;
4. Simplify corporate tax situation, use income tax to indicate tax situation, and introduce tax situation index;
5. Introduce the bank's settlement percentage and annual sales belong to bank index;
6. Introduce bank deposit, interest-bearing debt, new interest-bearing liability, repayment of interest-bearing liability, and deposit-to-loan ratio index;
7. Measure product market by market share, introduce market demand and product market index;
8. Introduce the proportion of technicians, R&D investment, R&D investment / paid-in capital, product technology index, and technical staff salary;
9. Introduce fixed asset, depreciation of fixed asset, depreciation rate, new fixed asset, paid-in capital index, and asset-liability ratio index;
10. Introduce profit, interest, and loan interest rate;
11. Introduce the sales revenue / interest-bearing debt index, the paid-in capital / interest-bearing debt index, and the guarantee capability index.

Based on the causal relationship diagram of the bank loan availability system for tech SMEs, with the three horizontal variables and six rate variables determined as the core, combined with the newly introduced variables, the bank loan availability system flow diagram of the SMEs is established.

Configuration of Simulation Parameters of Loan Availability Information Model

Before performing computer simulation, it is necessary to determine all the parameters involved in the loan availability information model, including constants, initial values of horizontal variables, table functions, and so on.

Configuration of Constants and Initial Values of Horizontal Variables. In order to simplify the information model and facilitate the simulation, the values of those variables that do not change significantly with time are approximately constant[4]. It is assumed that these variables do not change during the simulation. The value standard is to take into account the general situation of tech SMEs which does not affect the accuracy of simulation and is convenient for simulation. The specific value is shown in Table 4.

Table 4 Information model parameter values

parameter value			parameter value		
variable name	variable	unit	variable name	variable	unit
total personal assets	150	10k yuan	industry ranking	0	Dmnl
paid-in capital	100	10k yuan	quality	1	Dmnl
sales unit price	1	10k yuan / piece	policy support	1	Dmnl
sales revenue growth	1	Dmnl	interest rate	0.06	Dmnl
corporate debt service	3	Dmnl	depreciation rate	0.1	Dmnl
economic environment	4	Dmnl	production cost rate	0.2	Dmnl
credit environment	1	Dmnl			

Configuration of Table Function. Several table functions are used in the dynamic information model of loan availability system. The application of table function can deal with the lack of data in the system conveniently and effectively, and solve the nonlinear relationship between variables[5]. In the system dynamics information model of loan availability constructed in this paper, 14 factors are used in the table function, namely economic strength index, employment experience index, sales revenue index, product market index, tax situation index, annual sales belong to bank index, deposit-to-loan ratio index, product technology index, guarantee capability index, asset-liability rate index, technical staff salary, management salary, market demand, market share. These table functions are determined by reference to the scoring standards in the commercial bank's SMEs credit rating indicators system and the operation of SMEs under normal circumstances.

In this paper, such periodic functions are represented by continuous functions of the same trend. For example, the economic strength index is a table function with economic strength as an independent variable:

Economic strength index = with lookup (economic strength, ((0,0)-(10,3)], (0,0), (1,1), (2,2), (10,2))) (3)

Analysis of Loan Availability Information Model Simulation Operation

The initial variables, constants and table functions analyzed and set above are input into the system dynamics information model of loan availability for tech SMEs. Set the initial time of the information model as 0, the end time as 50, the time step as 1, and the time unit as year. After running, the information model can be simulated and analyzed.

Analysis of Credit Score and Credit Rating. After running the information model through Vensim PLE simulation, the dynamic changes of credit score and credit rating during the simulation period can be obtained, as shown in Fig. 1.

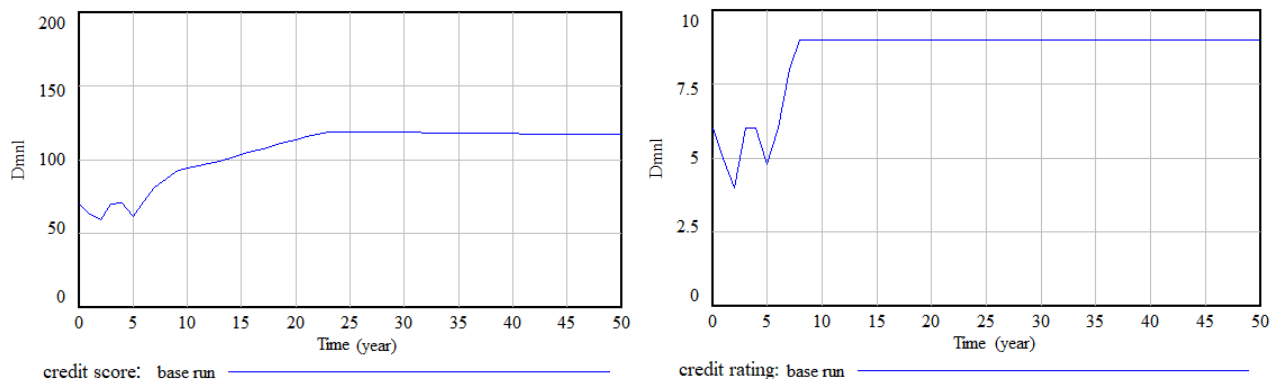


Fig. 1 Simulation results graphs of credit score and credit rating

According to the above analysis, it can be seen that in the first five years of the establishment of a tech SME, the credit rating of the company has not been high. According to Fig. 2, it can be seen that this is mainly affected by the low sales revenue index, tax situation index, annual sales belong to bank index and guarantee capability index. Among them, the sales revenue index, the tax situation index and the annual sales belong to bank index are all related to sales revenue. The guarantee capability index is only affected by fixed assets in this information model.

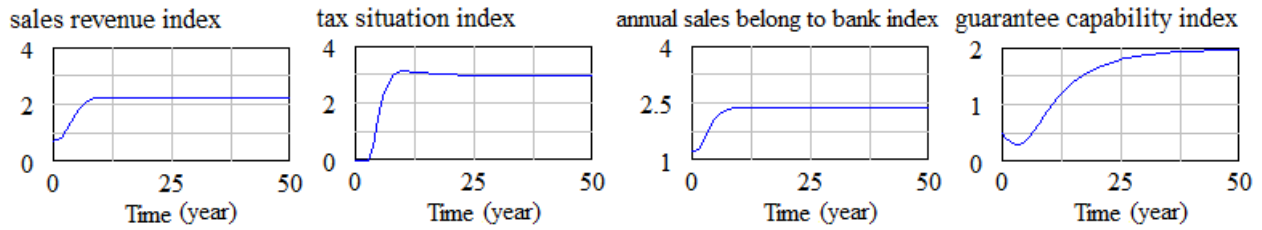


Fig. 2 Graphs of the reasons that affect enterprise credit score

Therefore, in the few years when the tech SMEs first started their business, that is, the entrepreneurial period of the enterprise, the lower credit rating of the SMEs was mainly because the mortgageable fixed assets and sales revenue were less, as shown in Fig. 3.

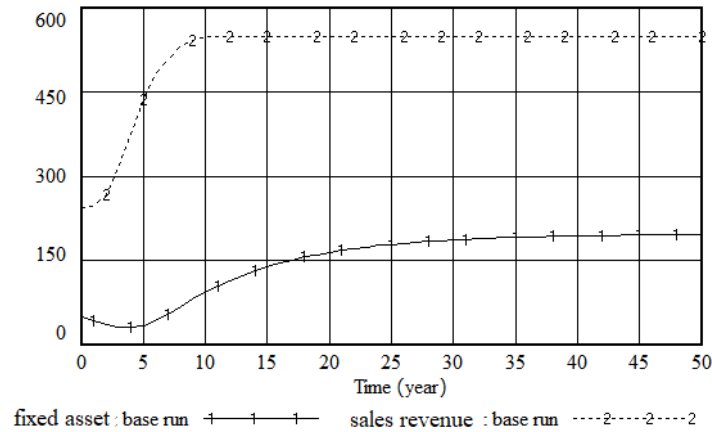


Fig. 3 Simulation results graphs of fixed asset and sales revenue

From the fifth year onwards, as the company goes out of the start-up period and enters the development period, after the business operation is gradually on the right track, the company's sales revenue and fixed assets continue to increase. Affected by these two factors, the sales revenue index, tax situation index, annual sales belong to bank index and guarantee capability index also increased, and the credit score and credit rating were also improved.

Analysis of Risk Limit. After simulating the information model, the dynamic change of the risk limit during the simulation period can be obtained, as shown in Fig. 4.

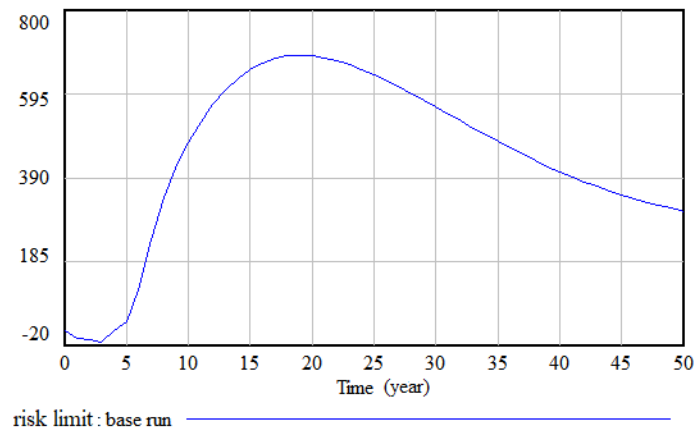


Fig. 4 Simulation results graphs of risk limit

From the results of the simulation operation, in the first four years of the establishment of the company, except for the first year, the risk limits for the remaining three years are all negative, that is, in the past few years, it is impossible for banks to lend to corporate banks. The availability of corporate bank loans is zero. This is basically consistent with the analysis of the credit rating in the previous section.

It is worth noting here that the curve of the enterprise risk limit has a striking similarity with the enterprise life cycle curve. It can be clearly seen from Fig. 5 that in the first five years of the establishment of a tech SME, the enterprise is in the start-up period, the company has less sales revenue, less mortgageable fixed assets, and the bank's credit rating for SMEs is low. Because the company's net assets are also small, the risk limit is very low too. In the 6th to 13th year of the establishment of the company, the company is in the growth period, the company's sales revenue begins to increase, the net assets increase significantly, and the company's credit rating is also at a relatively high level, the risk limit is getting higher and higher. In the 14th to 30th year of the establishment of the enterprise, the enterprise is in a mature stage. At this time, the sales revenue of the enterprise is relatively stable, and the net assets are relatively stable. The credit rating is still at a high level, and the risk limit of the company has been maintained at a relatively high level. After 30 years of establishment, the company has entered a period of recession. Although the company's sales revenue is stable, the credit rating is also maintained at a high level. However, as the company's net assets began to decrease, the risk limit began to decline.

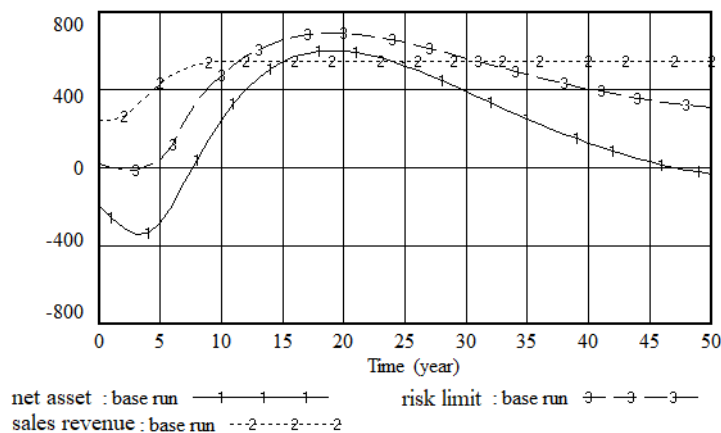


Fig. 5 Simulation results graphs of net asset, sales revenue and risk limit

Test of Loan Availability Information Model

The model test mainly starts from the authenticity and effectiveness of the information model. The model test of this paper adopts the following system boundary test and model operation test.

System Boundary Test. There are 3 horizontal variables involved in this information model, 6 rate variables, 13 constants, and 47 auxiliary variables, including all indicators of bank credit ratings for SMEs and the risk limits of enterprises. In this paper, the bank loans availability of tech SMEs can be basically reflected by these variables and their mutual relations. Therefore, it can be considered that the boundary of the constructed information model is approximately consistent with the actual system.

Model Operation Test. From the curves and data generated by simulation, it can be seen that the changes of various indicators are basically the same as the growth trajectory of enterprises in the theory of enterprise life cycle growth, as shown in Fig 6. Therefore, it can be considered that the information model constructed is true and effective.

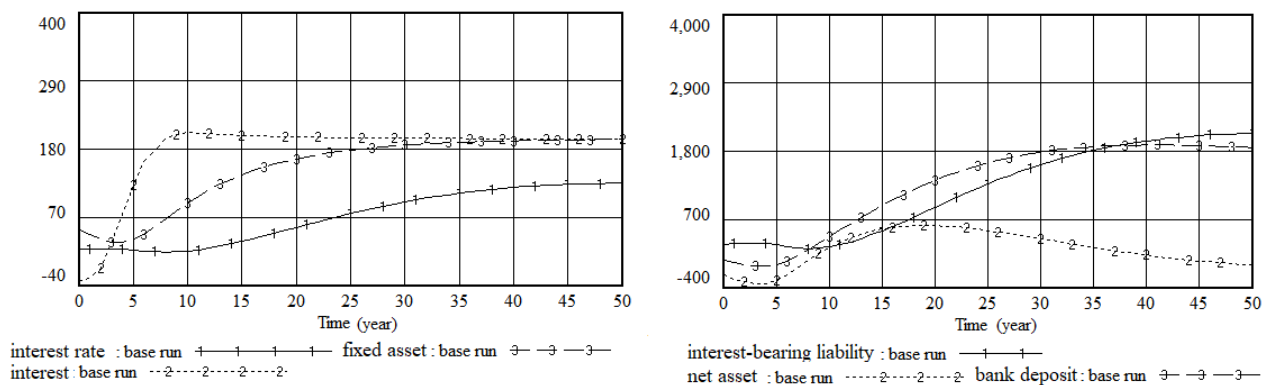


Fig. 6 Simulation results graphs of each indicator

Summary

Based on the analysis of banks' credit policies for SMEs, this paper combines the living environment and characteristics of tech SMEs, and uses the idea of informatization and the theory of system dynamics to construct the system dynamics information model of bank loans availability for tech SMEs. By configuring the parameters of the information model, the model simulation is carried out, and the growth situation and the changes of availability indicators of tech SMEs are obtained. It not only provides a scientific method for the research of tech SMEs to improve the availability of their loans, but also provides quantitative research tools for the follow-up research on financing difficulties of other types of SMEs.

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