15th Triennial World Congress, Barcelona, Spain

Leverage Firm Technological Competence via System Dynamics Modeling and Simulating Technique

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Abstract: In this paper, the system dynamics model of technological competence of the firms and capital accumulation was set up. By computer simulation and policy analysis of this model, the interaction and dynamic development of technological competence and capital accumulation was worked out. Furthermore, the optimal ratio between importing and indigenous R&D expenditure as well as optimal rate of capital accumulation was obtained.

Key words: System Dynamics, Technological Competence, Computer Simulation, Capital Accumulation, Optimal R&D Ratio

During the past decades, Chinese industry has made great progress in technological innovation. It is complex results of the changing political and technological environments. The critical factors of successful innovation are that Chinese industry has paid much attention to the acquisition and absorption of foreign advanced technology until 1980s. Since late 1980s, many Chinese firms began to innovate with portfolio view. This new pattern of innovation greatly enforced the competitiveness of their products. Up to late 1990s, a lot of Chinese firms had built strong technological competence and innovative capabilities. So they began to deepen their innovation management by managing internal and external technological and organizational knowledge, and by building their innovative network.

Many Chinese firms rested deeply on using importing technologies, but did not commit themselves to assimilate the importing technologies. Thus made them relapsed into the vicious circle that is:

Import-----lag behind----- import again----- lag behind again.

According to our surveys to 22 firms, the expenditure rate used in technology assimilation was only 10.2% of the total amount used in technology importation. Comparing the statistical data of Chinese firms in 1986 and the data of Japanese firms in 60s also indicate this view (see table 1). In such low expenditure on technology assimilation, it is impossible for firms to innovate sustained and get competitive strength.

The resource allocation of the West Lake Electronic Co (WLE) was analyzed in the process of switching from technological importing to internal R&D. From the results of table 2, we know when the ratio between internal R&D and technological importing investment is 3.6 : 1, the increase rate of tech. competence is maximal. When the investment ratio on internal R&D is between 3.8% and 5.7%, the investment ratio on technology importing is between 0.7% and 2.6%, the increase rate of tech. competence is more. So WLE may improve its investment ratio to increase accumulation rate of tech. competence.

Table 1 The expenditure ratio of technology importation and assimilation in China and Japan

Nation	Machine-building industry	Chemical engineer industry	Metallurgy	Electrical industry	Total in-average
China	5.43:1	185.2:1	7.12:1	11.78:1	10.79:1 (1986)
Japan	1.4:1	1:81	1:11	1:10	1:4.9 (1963)

(Reference: the data of Chinese firms come from Reference 1 and 2)

Table 2 Simulation results of increase rate of Tech. competence

The capital ratio (%) on internal R&D	The capital ratio (%) on technological importing	Increase rate (%) of Tech. competence (1995)	Increase rate (%) of Tech. competence (1996)	Increase rate (%) of Tech. competence (1997)	Increase rate (%) of Tech. competence (1998)
6.4	0.0	4.05	4.95	3.09	7.37
5.7	0.7	5.16	6.12	5.34	9.38
5.0	1.4	7.03	7.97	6.99	11.23
4.3	2.1	6.54	7.33	6.76	10.46
3.8 (actual)	2.6	5.28	6.80	6.00	9.86
3.1	3.3	4.67	5.65	5.46	8.17
2.4	4.0	4.34	5.43	5.55	6.92
1.7	4.7	3.55	4.77	4.98	5.78
1.0	5.4	4.23	4.96	5.67	5.99
0.0	6.4	3.09	3.78	4.76	4.93

1. The structure of SD model

The accumulation of technological competence is a complex process, there are many factors which affect its evolution and change. Here, we mainly analyze the impact of capital accumulation rate on technological competence process.

The SD model can be separated into four subsystems: technological competence, finance subsystem, market subsystem, and capital distribution subsystem (as shown in figure 1). There are multi-feedback interaction among these four subsystems, which determine the interaction advance of technological competence and the capital accumulation.

In this system, the gap of TC (technological competence) will be figured out first according to its existing technological capabilities and its anticipant technological capabilities, then select the accumulation path of TC according to its financial ability and industrial-technological dynamics.

The devotion to accumulation of TC breeds knowledge learning and knowledge creating, then knowledge learning and knowledge creating enforces technological capabilities, marketing competence and organizational capabilities. Moreover, this improves the effectiveness of accumulation path selection of Tech. competence. The accumulation of Tech. competence brings two feedback, it affects the accumulation path selection of Tech. competence through reducing the gap of Tech. competence on the one hand; on the other hand it affects the accumulation path selection of Tech. competence through improving the firm performance and enhancing financial ability. The main causal- effect of accumulation of is shown as figure 2.

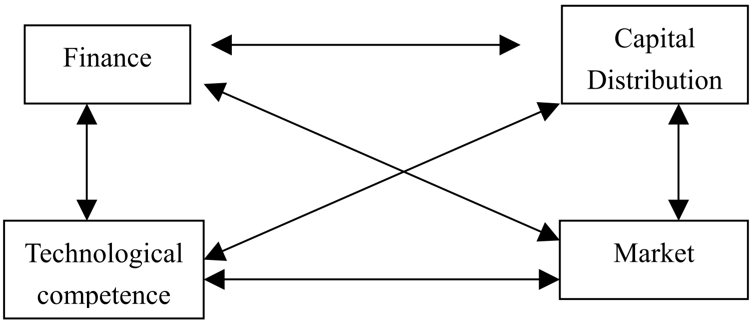


Figure 1 The structure of SD model

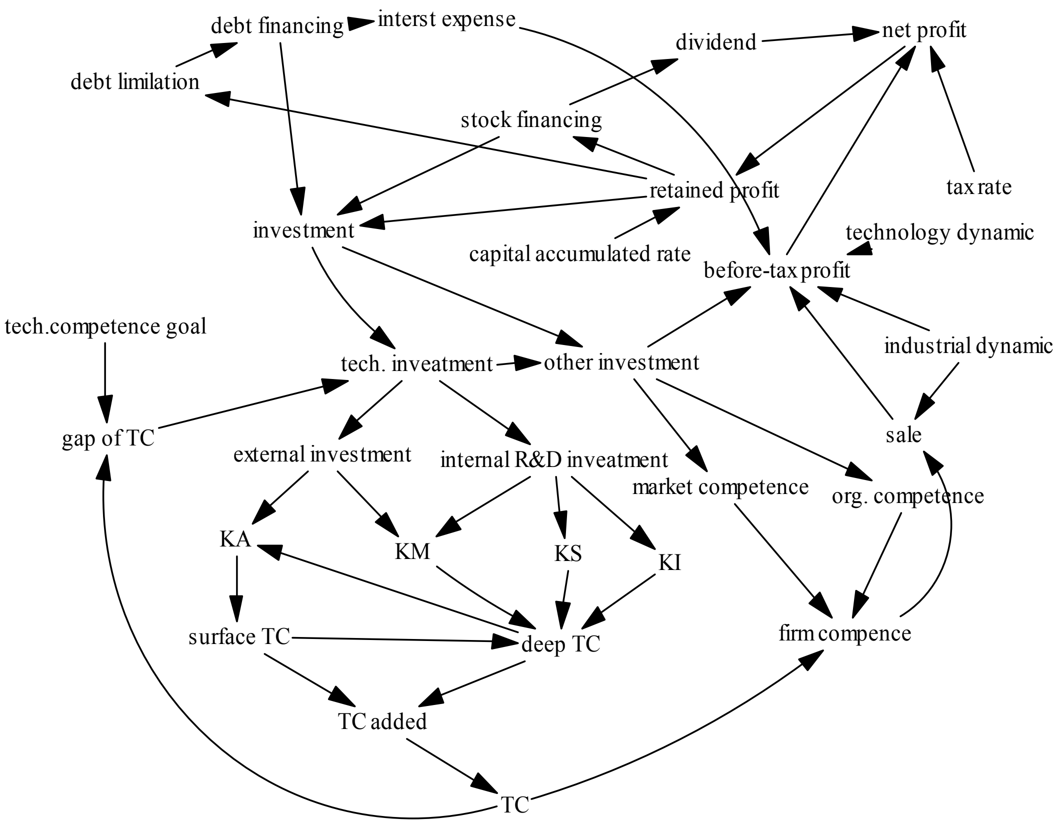


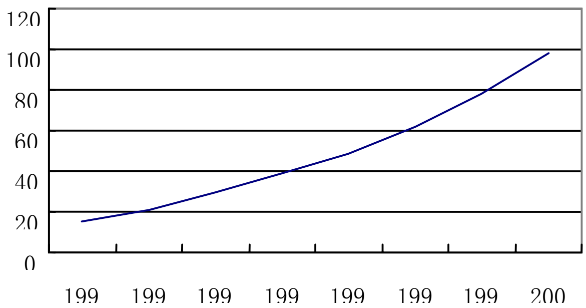
Figure 2 Simple illustration of causal-effect relation on accumulation of TC

In Figure 2: KA is knowledge assimilation; KM is knowledge fuse; KI is knowledge internalization; KS is knowledge sharing.

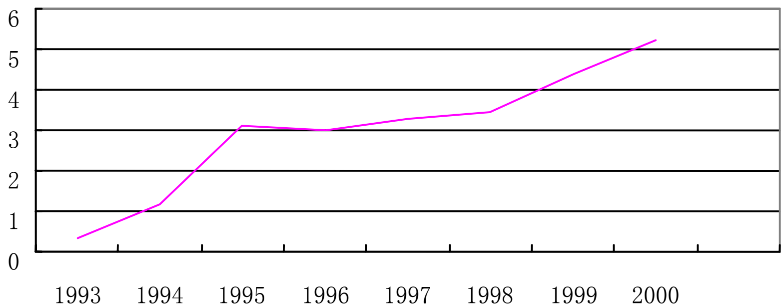
2. Validity test of SD model

We simulate the development of Eastern Telecommunication Ltd.Co.(EASTCOM) by using the SD model. We take the data of sale and profit in 1993 as the initial value of level variable of dynamic model, the results of simulating are shown as figure 3.

The data in table 3 showtabde 3 shows that the errors between simulation resultataon results and valuation results belongs to the rngs to te small, which validated the effectiveness of the system dynamic model.



sale： current ——— a hundred million



profit： current ——— a hundred million

Figure 3 The simulation result of EASTCOM

Table 3 Comparing the results of simulation and the results of valuation

(Unit: hundred million)

	1993	1994	1995	1996	1997	1998	1999	2000
sale（real value）	15	21.3	28.5	40.7	47.1	59.5	81.4	102.8
Sale （ simulating value）	15	20.8	29.4	39.1	49	61.8	78.2	98.5
Error in %	0	-2.3%	3.1%	-3.9%	4%	3.8%	-3.9%	-4.2%
profit（real value）	0.31	1.22	3.21	2.87	3.15	3.31	4.58	5.17
profit （ simulating value）	0.31	1.19	3.12	2.98	3.27	3.45	4.39	5.24
Error %	0	-2.4%	-2.8%	3.8%	3.8%	4.2%	-4.1%	1.3%

3．The policy analysis

Today, capital scarcity is the major problem in most Chinese firms. It's necessary to speed up the capital accumulation. So we mainly analyze the influence of different capital accumulation rate acting on firm development. By this, it is necessary to make estimation on the rate of capital accumulation.

We choose the increase rate of sale and technological competence index as analysis quotas. In this SD model, technological competence is defined as the weighted integrated value of four kinds of capabilities, that is: technological assets, technological organization, external technological network, and technological strategy.

In figure 4, the variety of sale's increase rate and technological competence were shown, while capital accumulation rate were 20%, 30%, 35%, 40%, and 50%.

From the simulated results of SD model, the Tech. competence index is in an obvious increasing trend as the capital accumulation rate varies from 25% to 40%. The higher the rate is, the faster Tech. competence leverage.

Furthermore, we study the condition that capital accumulation rate varies from 20% to 25%. The simulated results of SD model (as shown in figure 5) indicate that 20~22% is the lowest capital accumulation rate which can ensure Tech. competence increasing. So it's necessary for Chinese firms to keep the capital accumulation rate no lower than 20~22% .

On the other hand, when capital accumulation rate goes up to 35%, firm's Tech. competence rise obviously. When capital accumulation rate is 40%, the firm's Tech. competence and the increase rate of sale rise obviously (as shown in the figure) before 1997, but after 1997, the increase rate of sale began to decrease and Tech. competence almost didn't rise. If we study the change of Tech. competence further when the capital accumulation rate falls into the range between 35% and 40%. The simulating result in figure 6 indicates that around the 37% is best capital accumulation rate in this special case.

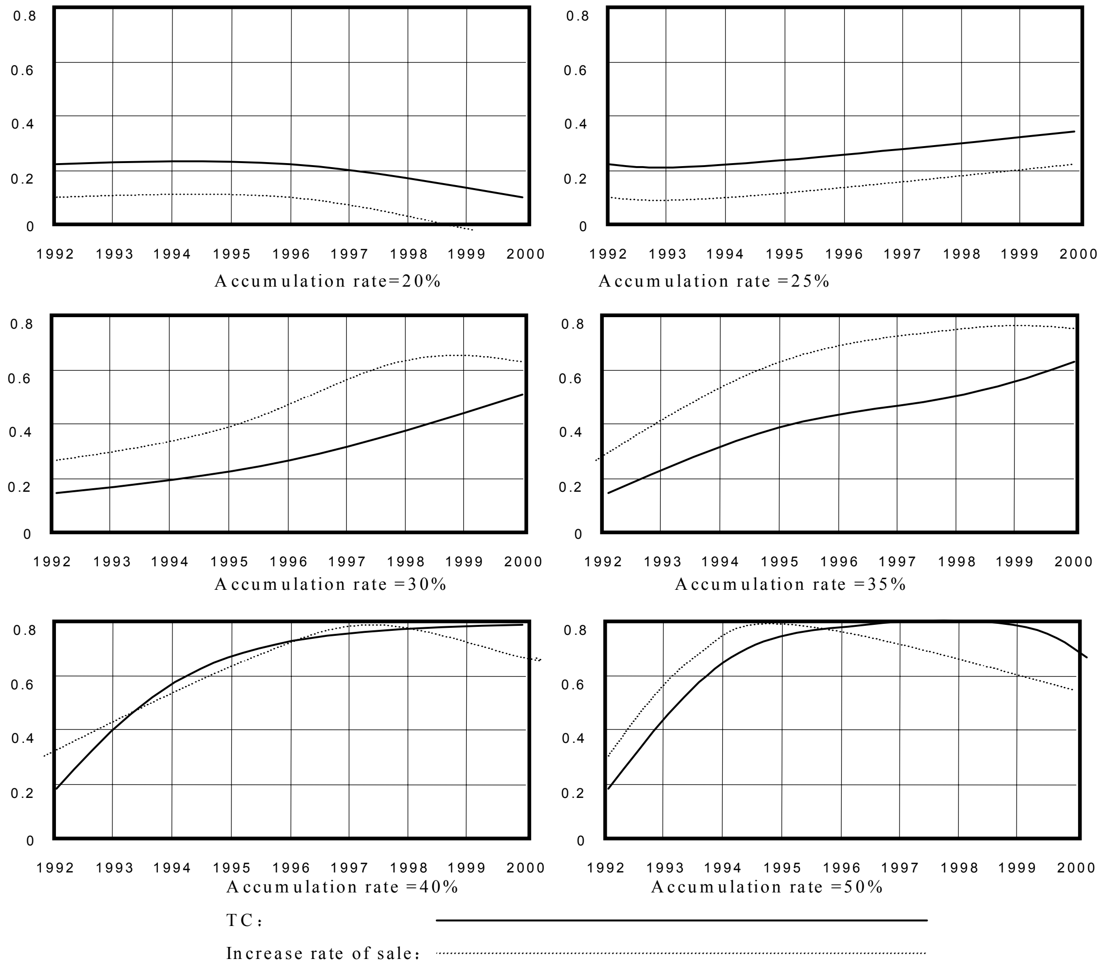


Figure 4 the impact of capital accumulation rate on firm development

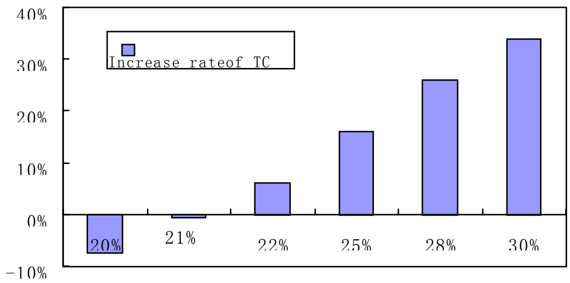


Figure 5 The breaking point of TC increase (1)

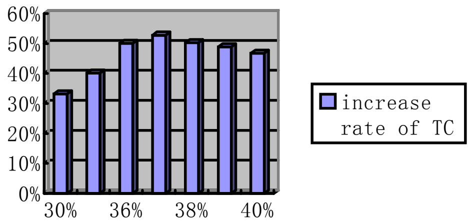


Figure 6 The breaking point of TC increase (2)

4. Brief Conclusion:

1. It is necessary to distribute R&D capital with right rate of importing and indigenous in order to go to 3I model from the vicious circle;
2. Firms must do themselves capital accumulation, then they have enough capital for indigenous R&D;
3. The impact of capital accumulation on tech. Competence is the result of interaction of many factors, so it is necessary to use SD simulating and modeling technique in order to find better rate of capital accumulation.

References

1 Mansfield E, Schwartz M and Wagner S. Imitation costs and patents: An empirical study, The Economic Journal, Dec,1981.

2 Bowonder,B., R&D Spending Patterns of Global Firms, Research and Technology Management, September-October, 2000.

3 R.S.Jonash, Strategic Technology Leveraging: Making Outsourcing work for you, IEEE EMR, Summer,1997, 90-96.

4 R.Veugelers, Internal R&D expenditures and external technology sourcing, Research Policy,26(1997),303-315.

5 Xu Qingrui, Guo Bing and Chen Jin, Managing Innovation Portfolio: Experiences and Lesson in China, IEMC 96 Proceedings of International Conferences on Engineering and Technology Management, Canada, 1996.