

**A Strategy for Enhancing Enterprise's Human Capital: A
System Dynamics Model for Resources Allocating**

--A Case of a High Technology Enterprise

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ABSTRACT

It is the critical task for decision makers of enterprises that how to develop enterprise's human capital and make the valuable decision of investment on human capital by fully utilizing the limited resources. This article deals with two investment decisions of human capital by the approach of system dynamics modeling: the resource allocation between different types of human capital and the suitable investment intensity which may be in the terms of the ratio of the training expenditure to sales. In this article, human capital of organization is divided into two types: general human capital and firm-specific human capital, and the employees be divided into two groups: Key employees and general employees. The system employed here consists of four sub-systems: workforce system, resource allocation system, operating & performance evaluating systems and competencies development system.. Through the analysis of interaction between these sub-systems and simulation results using the actual data, the suggestion for decision makers on the resource allocation on human capital investment will be given out.

KEYWORDS: competencies development; resource allocation; policy analysis

Introduction

Organizational human resource development, as a complicated system activity, involves not only how to implement various development activities, but also the resources allocation strategy. Resource is needed for workforce's competencies development. In this article, the input of competencies development refers to the expenditure on the activities of workforce competencies development and upgrading, including training expenditure, and other expenditure spending on formal or informal competencies development activities, such as seminars and conferences. Due to the timely delay of competencies development's benefits, we can't allocate competencies development resource on a short-term basis and in static perspective. Allocating competencies development resource involves three fundamental decision issues: 1) the intensity of input for competencies development, that is, the ratio of input to sales; 2) the internal

allocation proportion between special competencies development and general competencies development of workforce; 3) the workforce structure that is the ratio of general employee quantity to key employee quantity. As key employees and general employees vary in their competencies level, competencies structure, and employing costs, a reasonable ratio is needed for enterprise. The relationship of these three fundamental issues above between enterprise's performances is non-linear, dynamic, thus the system dynamics is the most appropriate tool used in these kind decision issues. This article deals with these decisions using system dynamics model based on the data of a actual of enterprise.

The Analysis of Resource Allocation System and Model Building

In resource allocation system, the intensity of resource input in competencies development activities determines the growth of organizational competences which in turn determines the enterprise performance in market, that is, the movement of enterprise sales. This sales movement will affect the quantity of competencies development resource available on the one hand and the movement of enterprise profits on the other hand. Meanwhile, the movement of the quantity and structure of workforce can affect the input intensity of competencies development per person and organizational profits whereby the change of salaries. Based on this theoretical analysis, four sub-systems, namely, workforce sub-system, resource allocation sub-system, competencies development sub-system and performance sub-system are formulated, and their interactive relationship and structure is as follows:

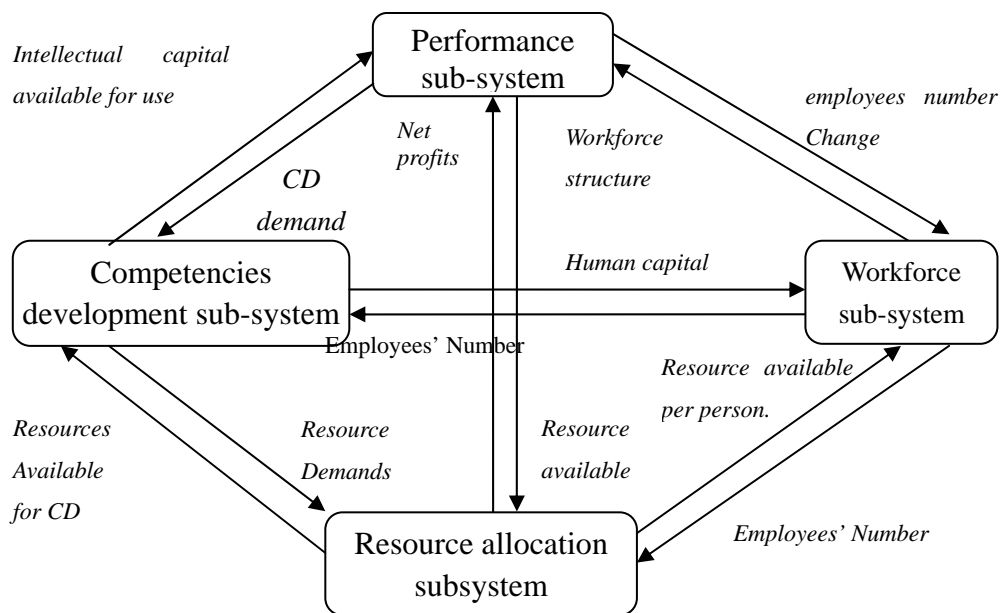


Figure 1: System Relationship and their Structure

The following is the system's operational mechanism:

- (1) Input intensity of competencies development determines the degree of growth in workforce competencies;

- (2) The movement of competencies determines the movement of enterprise performance(its sales and profits);
- (3) The movement of sales and profits in turn determines the total input of competencies development attainable, and the change of workforce number;
- (4) The change of workforce number also affects the resource input per person for competencies development and the change of organization profits.

Based on the above system analysis, a cause loop of competencies resource allocation system is represented as Figure 2.

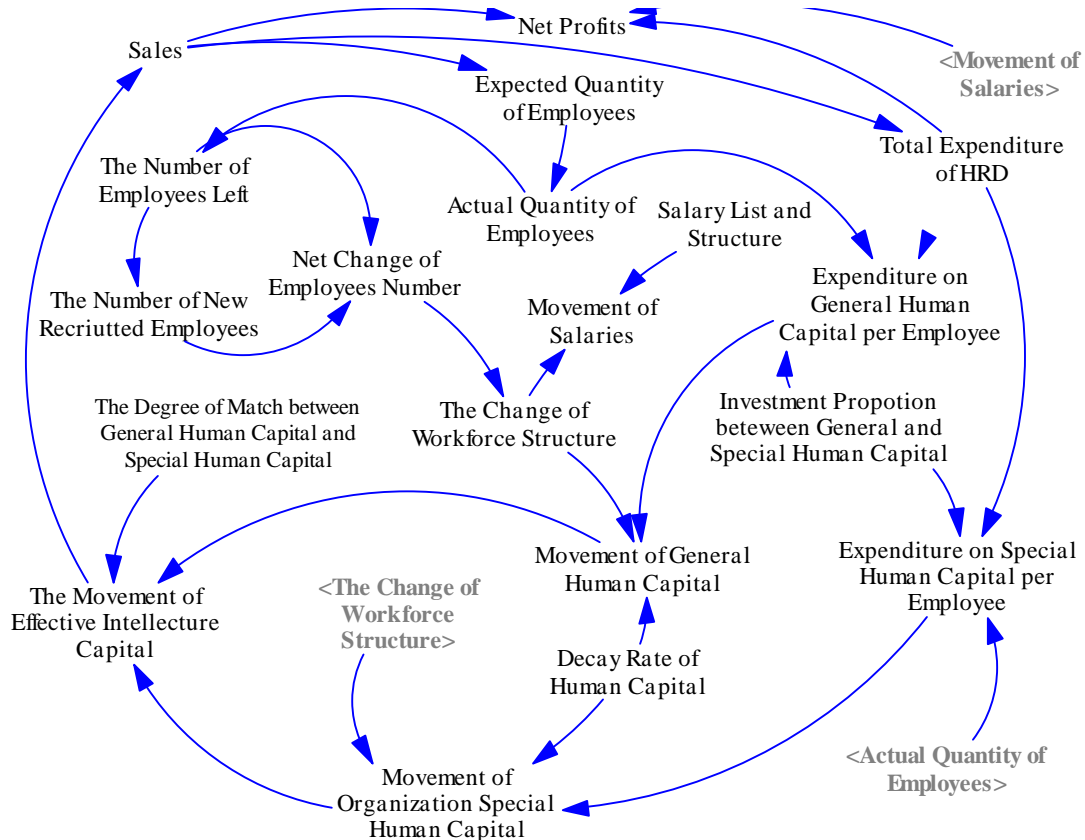


Figure 2: The Cause Loop of Resource Allocation

This cause chain illustrates the interactive relationship among these factors. Based on the cause loop, a flow chart of resource allocation system for competencies development is formulated and further model equations is made by using actual data to determine the model parameters. After the validation of this model, an actual enterprise system will be simulated, and the results from this simulation can be used for decision-making in enterprise resource allocation.

This model is based a large-scaled high-tech enterprise. The enterprise is specialized in research and production of all sorts of auto-operation equipment and delicate devices, and the majority of 1000 total workers are knowledge workers (Here this enterprise is just short for WHLG, as they required). The enterprise’s development highly depends on its workforce, esp. knowledgeable workers, so it attaches much importance to the cultivation and development of workers’ competencies and training expenditure is very high every year. The enterprise has been working on a reasonable resource input ratio so

that they can avoid investing wastefully or insufficiently. Too high investment may lead to cost increase and insufficient investment may hinder sustainable development and dampen competitiveness. According to the analysis, system flow chart is formulated as Figure 3.

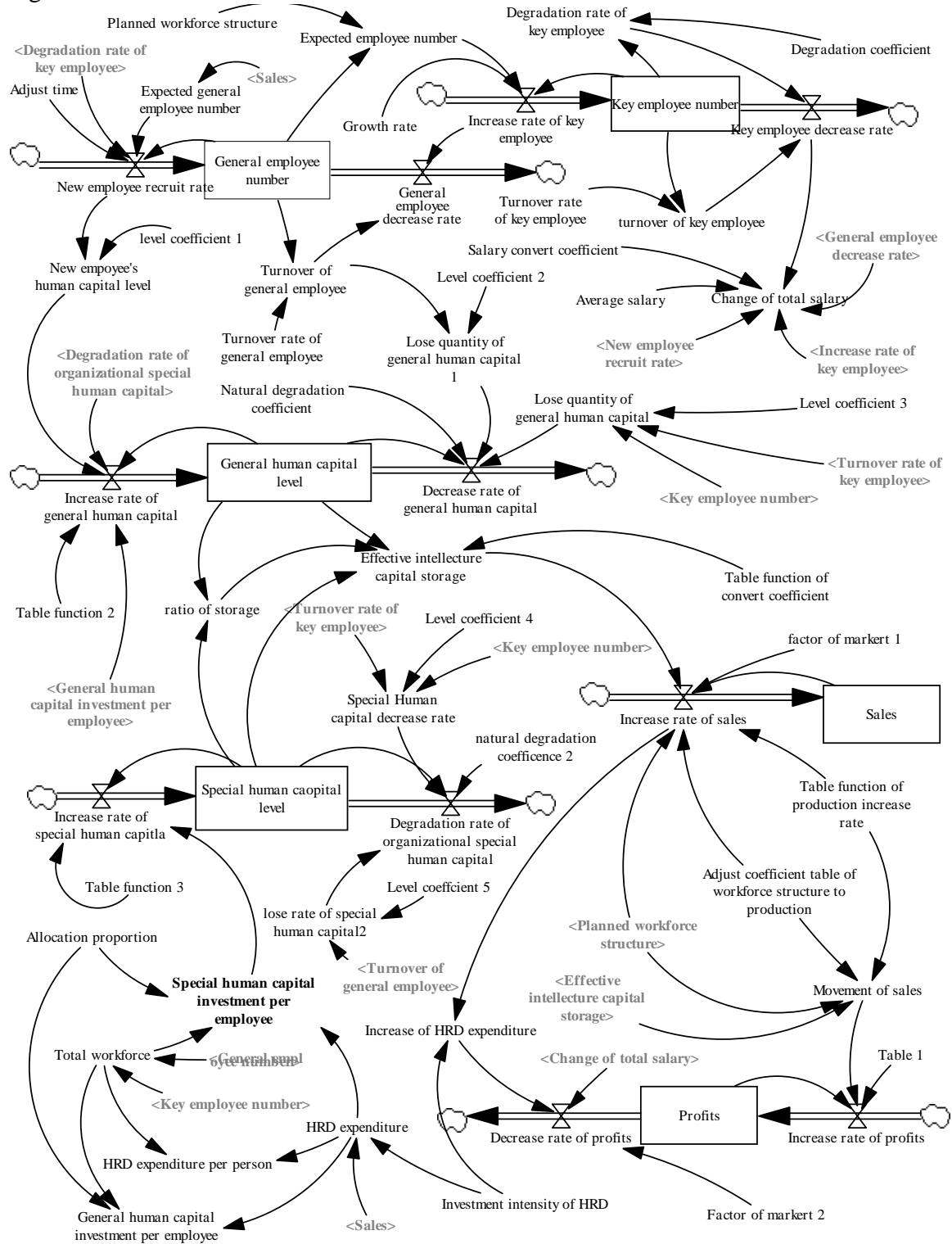


Figure 3: The Flow Chart of Competencies Development System

Model validation

The premise for using simulation result as decision information is validity of the model. Therefore, model should be validated. The validity of system dynamic model chiefly lies in the consistency between model parameter and the actual system, and this consistency lies in two facets: whether the model's structure can represent the structure of the actual system; the degree of consistency between the simulation result and actual data.

Applying system dynamic model simulating organization structure and system in order to provide information for enterprise decision-making, a lot of research has been carried out, e.g. the organizational capital increase system model constructed by Xiaojun Xu(2000), the system model of enterprise technical competencies increase by Xiaoqing Zhao(2002), and the system model of knowledge production and resource allocation by Sveiby, Keith Linard & Lubomir Dvorsky(2002). These findings are just the first step in applying system dynamics to the decision making concerning the enterprise "soft" issues, and clearly illustrate the internal structure and their interactive relation in enterprise system. All of these provide valuable inspiration for the very formulation of the resource allocation system in this article. Because in the model formulation, the internal logical structure of this system is taken carefully into consideration, and the actual structure of this system is supposed to be faithfully represented; the focus in the model validation is on the consistency between the model performance and actual system data.

With the history data used as the data for the validation of the simulating consistency, a comparison between simulation value and actual value is made to determine the quality and validity of this model. In this comparison, sales, profits, total workforce and human resource development expenditure are used as validation indication, and the history data from 1997 to 2002 of this enterprise as the benchmark, the results are as follows:

Table 1: Comparison between actual data and simulation value for 1997 to 2002

year		1997	1998	1999	2000	2001	2002
Sales (10,000RMB)	Simulation value	14751.1	14904.9	15318.4	15902.9	16517.5	17179.2
	Actual value	14250.2	14695.4	15490.5	16510.1	16020.4	17578.6
	Error r	3.52%	1.43%	-1.11%	-3.68%	3.10%	-2.27%
Profits (10,000RMB)	Simulation value	1616.25	1835.96	2068.51	2301.51	2512.89	2724.7
	Actual value	1590.31	1810.03	2069.01	2304.32	2513.5	2723.82
	Error r	1.63%	1.43%	-0.02%	-0.12%	-0.02%	0.03%
Number of total employees	Simulation value	949.333	925.451	924.066	938.7	965.232	995.746
	Actual value	919	915	910	940	950	1010
	Error r	4.44%	1.14%	1.55%	-0.14%	1.60%	-1.41%
Expenditure on HRD (10,000RMB)	Simulation value	147.511	149.049	153.184	159.029	165.175	171.792
	Actual value	145	150.23	155.26	155.5	165.2	170
	Error r	1.73%	-0.79%	-1.34%	2.27%	-0.02%	1.05%

According to the results of the value of every indication, the simulation value and actual value are well consistent, with a majority of error at 1 % and a minority of 3%, and there is no systematic error. Therefore, from the results it can be concluded that the model can represent the structure of actual system, and the model is valid, the simulation results can be referred to for decision making.

Modeling policy analysis

Resource allocation in enterprise is a complicated activity as the enterprise resource is limited and demands for resources are unlimited. Thus the issues as to the priority of utilization and allocation of limited resource arise. Further how the resource is allocated will affect not only the enterprise present performance, but also the future development in the long run. Therefore, three kinds of policy are analyzed fully: the reasonable input intensity of competencies development resource, the reasonable proportion for the internal allocation of competencies development resource, and the reasonable structure of workforce.

Effect of the input intensity of competencies development resource on enterprise performance and policy analysis for reasonable input ratio

In knowledge economics, enterprises attach increasing importance to the input for competencies development and training. Competencies development and training is used not only for improving workforce competencies but also for maintaining workforce and reducing turnover rate. The focus of investment in some enterprises in some western countries is “intellectual investment”. The professional training input in members of OECD accounts for approximately 2.5% of GDP. Motorola has an annual intellectual investment of 1 billion with great financial return(Yier, 2003), a United States-based education institution estimates that the ratio between input and benefits is 1:3 (Zhongxing Zhou, 2002). However, this investment effective lies within a certain scope; it is not always the-more-the-better matter from a cost-benefit perspective. As far as the input for competencies development is concerned, the low input can reduce costs, but it will further degrade the of workforce competencies, dampen enterprise long term development; at the same time too highly input will overburden enterprise, decreasing profit ratio sharply, due to the diminishing marginal return of competencies development investment.

Our investigation indicates that most enterprises input insufficiently for workforce competencies development in China, mostly below 0.5% (inputs to sales). Based on the above model, the future situation of the enterprise is simulated under different resource input intensities (resource input /total sales). This simulation is based the workforce structure parameter (key workers: general workers) and internal resource allocation proportion parameter (general competencies development input/ organization special competencies development input) at the fixed level of 2: 8 and 4:6 respectively. The following are simulating results as shown in Table 2.

According to the simulation, the enterprise’s performance will be on the decrease, and its size shrinks when input intensity below 0.5%. This is because insufficient input

results in insufficient renewal and recruiting of workforce, workforce competencies degraded, and in turn affects enterprise performance in the market with a decrease in sales, and further affect the resource attainable for competencies development. These form a vicious circle. If the input ratio is not increased, the enterprise will be doomed to bankruptcy ultimately.

When input intensity between 1% and 1.5%, enterprise is on the increase in total sales and profits, with their sizes expanding; and such a benefit circle promises a prosperous development pattern.

With an input intensity above 2%, total sales are on the increase. Profits are also on the increase initially, but will be on the decrease later on, and the higher the input intensity, the more sharp the decrease. In response to the increase in total sales, enterprises expand in size with the increase of workforce, e.g. at the intensity of 2.5%, up to 2010, workforce will be totaled 5375 in number. In this case of high resource input, enterprises are run by extensive-operation pattern, the increase in total sales highly rely on high resource input and expansion of enterprise scale. Under such circumstances, due to low efficiency in cost-benefit and growth in workforce, these enterprises are at loss, in spite of sales increase. In this way, it is concluded that too high resource input for competencies development violates the economic laws, thus not acceptable.

Table 2: The Simulation Results at Different Input Intensity

Input ratio	Year	2003	2004	2005	2006	2007	2008	2009	2010
0	Sales (10,000RMB)	3381	2468	1802	1315	960	701	512	374
	Profits (10,000RMB)	805	747	693	641	592	546	502	462
	Input per person (RMB)	0	0	0	0	0	0	0	0
	Total employee	612	561	514	471	432	395	362	332
0.5%	Sales (10,000RMB)	8959	7164	5515	4126	3016	2202	1607	1173
	Profits (10,000RMB)	957	879	815	757	702	649	598	551
	Input per person (RMB)	622	543	456	373	297	237	189	150
	Total employee	720	660	604	554	507	465	426	391
1.0%	Sales (10,000RMB)	17874	18575	19326	20143	21038	22022	23120	24410
	Profits (10,000RMB)	2939	3156	3393	3656	3950	4281	4659	5112
	Input per person (RMB)	1733	1736	1741	1745	1750	1756	1763	1774
	Total employee	1031	1070	1110	1154	1202	1254	1312	1376
1.5%	Sales (10,000RMB)	20496	22165	24096	26389	29199	32646	36986	42522
	Profits (10,000RMB)	3268	3592	3955	4377	4883	5440	6027	6615
	Input per person (RMB)	2717	2739	2762	2790	2825	2862	2909	2961
	Total employee	1132	1214	1309	1419	1550	1711	1907	2154
2.0%	Sales (10,000RMB)	22356	25265	29069	34054	40538	49040	60542	75865
	Profits (10,000RMB)	3438	3806	4150	4430	4580	4508	4070	3006
	Input per person (RMB)	3757	3840	3933	4027	4114	4201	4306	4389
	Total employee	1190	1316	1478	1691	1971	2335	2812	3457
2.5%	Sales (10,000RMB)	25132	29803	36158	45025	56791	73123	95259	125557
	Profits (10,000RMB)	3456	3650	3681	3424	2661	1136	-1637	-6285
	Input per person (RMB)	4932	5080	5239	5414	5517	5662	5751	5840
	Total employee	1274	1467	1725	2079	2573	3229	4141	5375

To make a easy job for readers, simulation result of each item in the case of resource input intensity are represented in Figure 4.

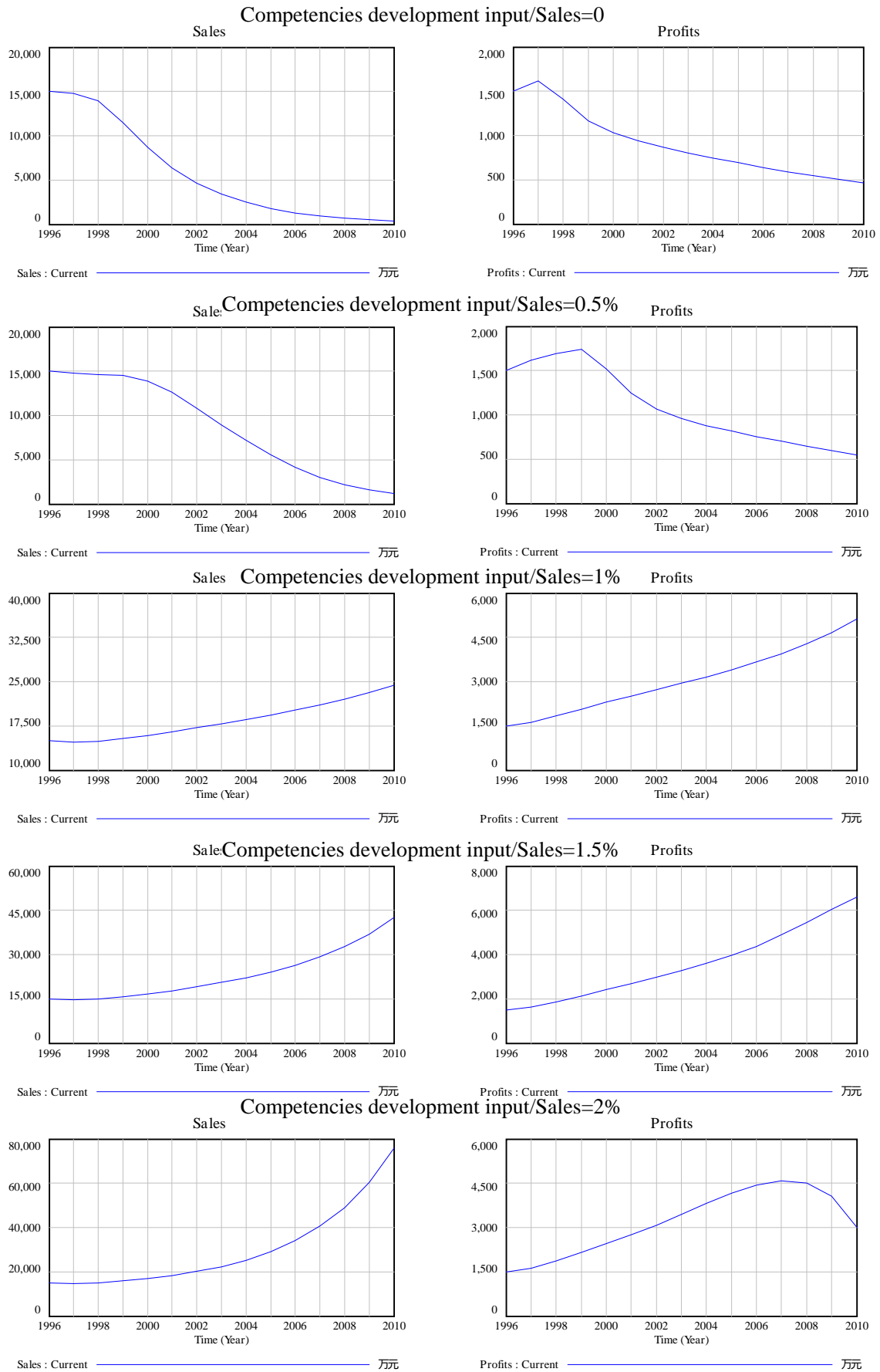


Figure 4: The enterprise's performances at different input ratio

From the tendency of the change of enterprise's total sales and profits, resource input ratio for competencies development is supposed to be at 1.5%. Such being the case, total sales and profits are all on the increase in figure. A benign development witnesses moderate expansion in enterprise scale, e.g. with registered workforce totaled 1000 in 1996 and up to 2154 in 2010.

Policy Analysis of Resource Internal Allocation Proportion for CD

Enterprise performance is not only determined by the amount of resource input for employees' competencies development, but also by internal allocation proportion of this resource. In terms of competencies' type of enterprise, human capital can be classified as organizational special human capital and general human capital (GHC). Special human capital (SHC) refers to the human capital that can not be transferred among different organizations, and is key competencies special to organization; this sort of capital is the organizational competence foundation for sustainable competitiveness advantage, and is also the focus which organization develops. As for general human capital, it is transferable between different organizations and available in the market. For an individual, his competencies can also be classified as organizational special competencies and general competencies. Conceptual classification for human capital and competencies does not mean both of them can function separately. To fulfill a certain task requires workers holding not only organizational special competencies but also general competencies. General competencies is the base of special competencies to exert their function, and the level of general competencies can restrict the degree of special competencies be used. In addition, in changing environment, moderate input for general competencies development can enhance the flexibility and responsiveness to the external environment. According to classical economics, resource inputting for organizational special human capital is sufficient, developing for general competencies is the responsibility of employees themselves. In consideration of inseparability between general competencies and special competencies, input for general human capital for a person with certain organization special competencies is necessary. If not, the special competencies will be greatly hindered in terms of its benefits as it has no corresponding new general competencies to work along. If enterprises recruit new employees from job market with ready new general competencies, the special competencies acquired by former workers are subjected to loss. In this way special human capital and general human capital together constitute the competitiveness for an enterprise, and these two forces should be at a proper proportion. As the returns of investment on general competencies and special competencies are different, an optimal investment proportion between general human capital and special human capital is to be sought in the resource allocation for competencies development. Based on the system dynamic model, the operations of this enterprise at various proportions (investment for general human capital /investment for special human capital) are simulated. The findings are as in Table 3 and Figure 5.

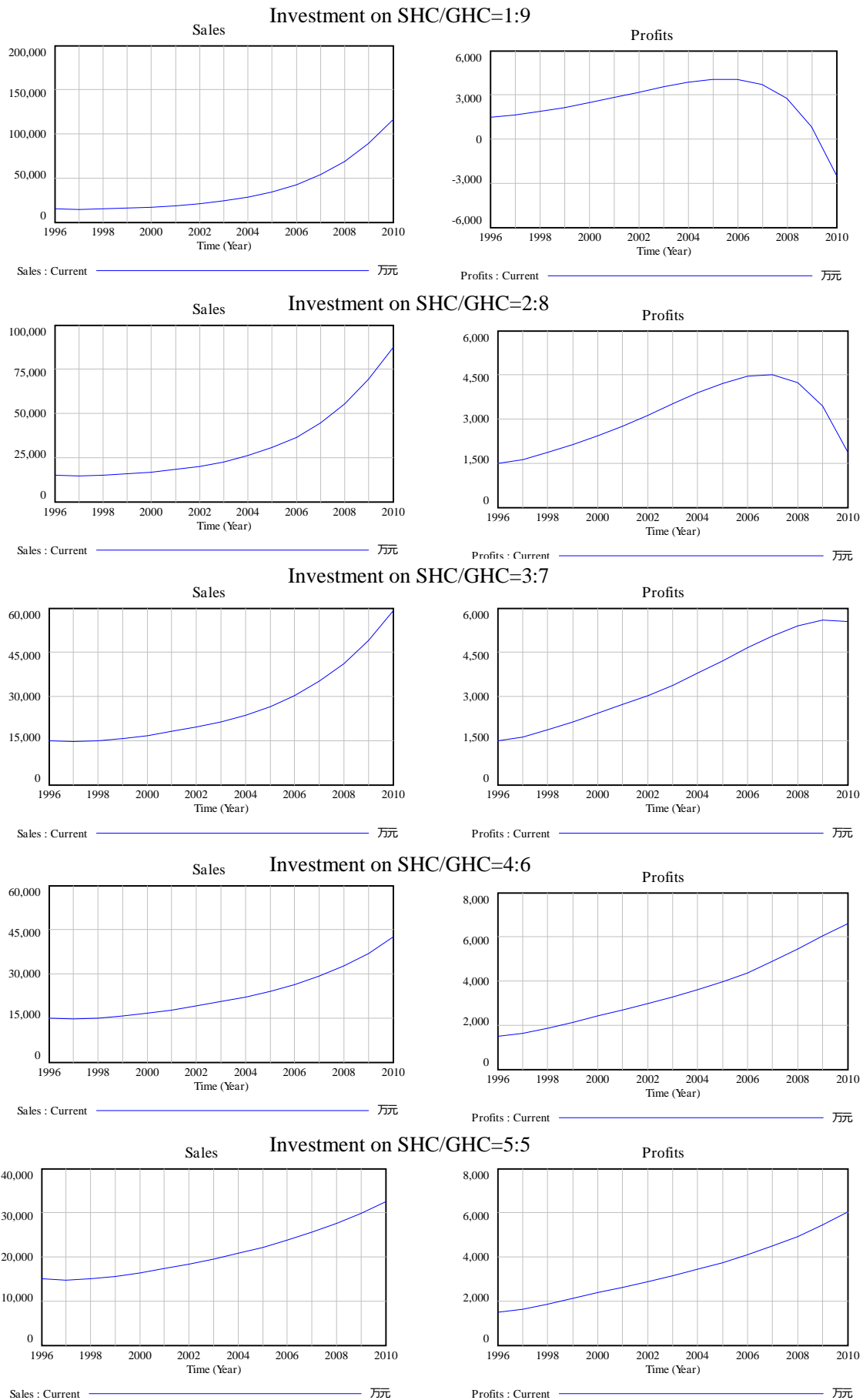


Figure 5: The Enterprise's performance at different allocation proportion

Table 3: Simulation Results at Different Allocation Proportion

proportion	year	2003	2004	2005	2006	2007	2008	2009	2010
0:10	Sales (10,000RMB)	25269	30543	38036	48082	62149	81294	107326	142771
	Profits (10,000RMB)	3550	3792	3862	3592	2806	1126	-1911	-7014
	Input per person (RMB)	2997	3112	3235	3310	3407	3464	3511	3547
	Total employee	1265	1472	1763	2179	2736	3521	4586	6037
1: 9	Sales (10,000RMB)	23922	28258	34198	42475	53519	68778	89119	116456
	Profits (10,000RMB)	3544	3858	4064	4070	3697	2746	822	-2537
	Input per person (RMB)	2929	3029	3129	3235	3304	3388	3431	3472
	Total employee	1225	1399	1639	1969	2430	3045	3897	5031
2: 8	Sales (10,000RMB)	22579	25982	30533	36557	44523	55186	69171	87323
	Profits (10,000RMB)	3508	3888	4220	4451	4497	4231	3442	1860
	Input per person (RMB)	2851	2937	3021	3099	3172	3244	3296	3332
	Total employee	1188	1327	1516	1769	2106	2551	3148	3931
3: 7	Sales (10,000RMB)	21370	23668	26559	30277	35083	41206	49002	59161
	Profits (10,000RMB)	3376	3782	4211	4647	5057	5392	5588	5551
	Input per person (RMB)	2765	2814	2864	2923	2984	3039	3090	3149
	Total employee	1159	1262	1391	1554	1763	2034	2379	2818
4: 6	Sales (10,000RMB)	20496	22165	24096	26389	29199	32646	36986	42522
	Profits (10,000RMB)	3268	3592	3955	4377	4883	5440	6027	6615
	Input per person (RMB)	2717	2739	2762	2790	2825	2862	2909	2961
	Total employee	1132	1214	1309	1419	1550	1711	1907	2154
5: 5	Sales (10,000RMB)	19541	20811	22219	23784	25526	27537	29860	32546
	Profits (10,000RMB)	3155	3439	3751	4096	4481	4927	5442	6036
	Input per person (RMB)	2672	2687	2701	2713	2724	2741	2759	2778
	Total employee	1097	1162	1234	1315	1406	1507	1623	1758
6: 4	Sales (10,000RMB)	17500	17968	18435	18918	19489	20166	20964	21900
	Profits (10,000RMB)	2837	3001	3169	3351	3584	3854	4169	4533
	Input per person (RMB)	2565	2566	2565	2566	2576	2589	2603	2620
	Total employee	1024	1050	1078	1106	1135	1168	1208	1254

According to the simulation results, the profits indication show that the reasonable allocation proportion for general human capital and special human capital should be at 4:6.

Policy Analysis of Reasonable Employees' Structure

Maintaining the stability and flexibility of workforce is a challenge in management. On one hand, the turbulent nature of environment requires flexibility to keep adaptability and responsiveness to the environment. Meanwhile, business management also requires stability in order to keep operation continually. If workforce are classified as general workers and key workers and managed accordingly; the flexibility, continuity of the enterprise can be achieved through the flexibility of general workers, the stability of key

workers. This should be a new approach under these new circumstances, and a reasonable structure is needed for an enterprise. Otherwise, an enterprise can not coordinate flexibility and stability as too many or too few key workers all lead to failure in balancing flexibility and stability. This is because too many key workers will not satisfy the requirement of flexibility and too many general workers will not satisfy the requirement of stability and cannot form the core competence of enterprise. Another, there are different in training and employing cost, human capital level and human capital structure of key worker and general worker. The following is the simulation result of the enterprises with different workforce structure, as shown in Table 4 and Figure 6:

Table 4: Simulation Results in Different Employee Structure

Structure of employee	year	2003	2004	2005	2006	2007	2008	2009	2010
0	Sales (10,000RMB)	6692	5129	3763	2662	1838	1261	909	722
	Profits (10,000RMB)	1121	933	781	658	556	471	401	342
	Total employee	543	489	441	397	357	322	289	261
	Input per person (RMB)	1847	1572	1281	1006	772	588	471	416
1:9	Sales (10,000RMB)	12326	11606	10803	9928	9013	8093	7180	6287
	Profits (10,000RMB)	1531	1314	1123	971	858	774	701	632
	Total employee	724	688	647	603	555	505	459	417
	Input per person (RMB)	2552	2531	2504	2470	2437	2404	2348	2264
2:8	Sales (10,000RMB)	20496	22165	24096	26389	29199	32646	36986	42522
	Profits (10,000RMB)	3268	3592	3955	4377	4883	5440	6027	6615
	Total employee	1132	1214	1309	1419	1550	1711	1907	2154
	Input per person (RMB)	2717	2739	2762	2790	2825	2862	2909	2961
3: 7	Sales (10,000RMB)	17273	17832	18431	19076	19773	20534	21381	22325
	Profits (10,000RMB)	1207	1192	1169	1137	1092	1032	955	855
	Total employee	1113	1147	1183	1222	1264	1309	1358	1412
	Input per person (RMB)	2328	2332	2337	2342	2347	2354	2362	2372
4:6	Sales (10,000RMB)	16308	16501	16677	16855	17045	17246	17461	17691
	Profits (10,000RMB)	-686	-849	-1002	-1151	-1299	-1453	-1615	-1789
	Total employee	1210	1232	1251	1269	1285	1301	1317	1334
	Input per person (RMB)	2022	2009	1999	1993	1990	1989	1989	1990
5:5	Sales (10,000RMB)	15691	15607	15448	15211	14894	14456	13849	13098
	Profits (10,000RMB)	-2711	-2794	-2773	-2641	-2415	-2077	-1625	-1121
	Total employee	1362	1383	1390	1391	1383	1368	1343	1306
	Input per person (RMB)	1728	1693	1667	1640	1615	1585	1547	1504

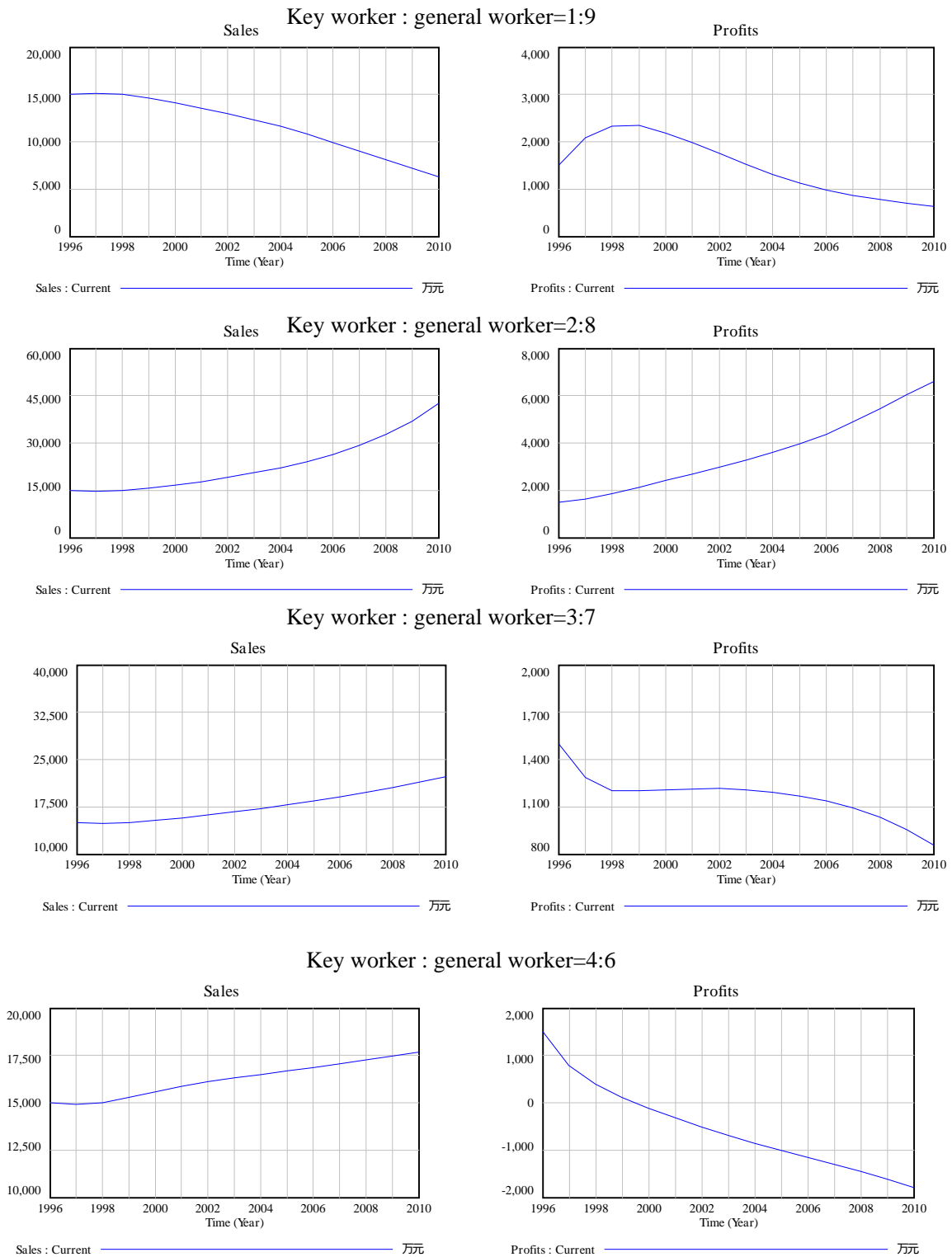


Figure 6: The Enterprise's performance under different structure of employee

From the simulation we can see that too few key workers (at a ratio of below 1:9) would result in sales and profits reduced sharply after certain time point. This is because enterprise core competences can not be maintained and developed, leading to enterprise loses sustainable competitiveness. With key workers at the ratio of over 3:7, the large

number of key workers adds cost to human capital investment and salary expenditure, ultimately lead to high management cost. The large number of key workers also results in enterprise's management rigidity, and the decrease in sales and profits. As far as the enterprise concerned, the optimal ratio between key workers and general workers should be 2:8.

Conclusion

The above research on human resource development system is based on a certain enterprise, the initial parameters are from the enterprise, thus the simulation results can be used for its decision making. Owing to the variation in different enterprises, some initial parameters and table functions for modeling also vary, so the optimal ratio and proportion gained from simulation may not be the optimal ratio of all enterprises, even though the modeling can represent some basic rules in human resource management. It is highly recommended that the model built above should be used based on corresponding parameters inferred from the real situation in a certain enterprise so that helpful information can be obtained for decision making.