FACTOR ANALYSIS ON IMPROVING THE PRODUCTIVITY OF THE NONFERROUS METALS INDUSTRY (1)[1]

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ABSTRACT

The productivity of China's nonferrous metals industry during 1980–1990 has been analysed. The important factors which constrain the productivity of the nonferrous metals industry have been studied, the methods of improving the productivity of the nonferrous metals industry have been discussed.

Key words: nonferrous metals industry productivity constraining factors improving

1 INTRODUCTION

China's nonferrous metals industry has been greatly improved in the 1980's, but at the same time, various contradictions and problems exposed. The purpose of the present paper is to identify, analyze, and suggest solutions for these problems.

2 FACTORS EFFECTING THE PRODUCTIVITY OF THE NONFERROUS METALS INDUSTRY

Productivity, the ratio of output to input, can be decomposed to many concrete indices which can serve as indicators of productivity. Productivity consists of the productivity of human labour productivity, materialize labour productivity and total labour productivity. According to the production management features of the nonferrous metals industry, labour productivity, captial productivity material consumption productivty and value productivity are chosen to comprehensively represent the productivity of the nonferrous metals industry and its development trends.

2.1 *Exhibition of Indices*

2.1.1 The Calculation and Meaning of the indices

1 Labour Productivity

Annual output of nonferrous metals per person = total output of nonferrous metals / number of employees, (t / p.a).

Annual net value of nonferrous metals output per person = net value of output of nonferous metals / number of employees, (RMB yuan / p.a)

2 Capital productivity (%)

Net value of output of unit capital = (net valve of output / management capital) × 100%.

where management capital is composed of fixed and circulating capital, fixed capital is calculated by averaging annually initial value of the fixed capital and circulating capital is average remaining sum of the total circulating capital.

3 Materialize consumption productivity (%)

Net value of output of unit material consumption = (net value of output / value of materials comsumption)

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× 100%

4 Cost productivity (%)

Net value of output of unit production cost = (net value of output / cost) × 100%

From above formules, we can get value labour productivity = capital intensive rate (capital per person) × capital productivity = material consumption rate (Annual material consumption per person) × material consumption productivity. = cost intensive rate (Annual productivity cost per person) × cost productivity.

It is implied that the variations in labour productivity are effected not only by the input structure, but also by the efficiency of the utilization production materials. The input structure is an extensive factor while the utilization efficiency of production materials is an intrisic factors.

2. 1. 2 Results of Calculation of Indices

The annual productivity of the nonfeerous metals industry and the subindices for the beried 1980–1990 are shown in Table 1.

Using the data in Table 1, the orbits and trends in productivity are illustrated in Fig. 1 ~ Fig. 5

1. 2 *The trends of Variations in Productivity and their analysis*

It is shown in Table 2 that the variation of L.P (labour productivity), C.P (capital productivity), M.C.P (material consumption productivity (VP) (Value productivity) in number, range and rate between 1980 and 1990.

2. 2. 1 Labour Productivity

In the period of 1980 ~ 1990, the object labour productivity (O.L.P) increased at steadily higher rates, except the decline in 1981 and 1982. The annual O.L.P per person increased with a growth rate 66.72%, and the average annual growth rate was 6.59%.

The value labor productivity has almost no periodically irregular variations except those in 1989 and 1990. The capital productivity (C.P) varied some what sharply. The average value of C.P in 1981 ~ 1985 was higher than that in 1976 ~ 1980. And the value labor productivity in 1986 ~ 1990 is higher than that in 1981 ~ 1985. During this period, the M.C.P. declined sharply and restricted the increase of labour productivity. At the same time, the capital intensive rate, material consumption intensive rate increased at steadily higher rates. Their variation trends are similar to those of labour productivity (L.P). Therefore, the increases in the capital intensive rate and material consumption intensive rate are essential factors promoting the growth of L.P.

In 1989, the positive periodic variation in the labour productivity of (911 RMB Yuan /

Table 1 Productivities and their subindices of the nonferrous metals industry (current prices)

Subject	Unit	Years											Annual average	
		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	6 5	7 5
1	t/(p.a)	1.432	1.370	1.310	1.430	1.504	1.600	1.715	1.851	1.923	2.036	2.184	1.441	1.948
2	RMB Yuan/p.a	3379	3478	3481	3610	4050	4980	5749	6676	7692	9487	8906	3928	7752
3	%	19.45	18.69	18.03	16.85	18.15	20.29	20.63	22.20	23.22	24.15	18.66	18.47	21.62
4	%	38.13	37.46	35.04	33.04	33.37	33.62	33.32	34.00	33.22	30.22	25.47	34.01	30.37
5	%	34.44	32.01	31.43	30.15	30.17	30.28	31.69	30.42	29.57	27.07	22.47	30.72	27.35
6	RMB Yuan/p.a./p	19434	18608	19312	21419	22315	24544	27871	30070	37127	39277	47721	21270	35857
7	RMB Yuan/p.a./p	9912	9808	9934	10925	12138	14813	17253	19636	23151	31411	34966	11550	25525
8	RMB Yuan/p.a./p	10973	10864	11074	11975	13423	16447	18139	21946	26014	35043	39164	12787	28345
9	RMB Yuan/p.a./t	9560	9696	10244	10285	10764	12371	13411	14218	16040	20086	20093	10745	17077
10	RMB Yuan/p.a./t	2639	2538	2658	2554	2693	3112	3352	3608	4000	4659	4079	2727	3978
11	RMB Yuan/p.a./t	6921	7158	7586	7731	8071	9259	10059	10610	12040	15427	16014	8018	13099

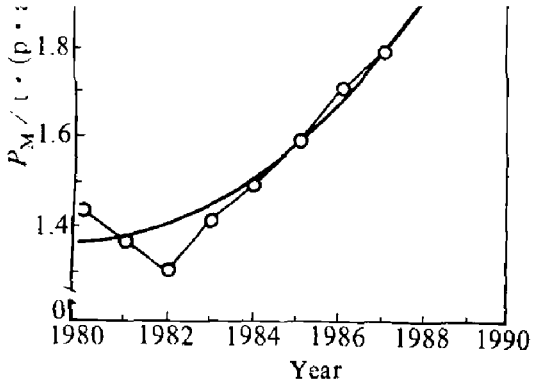

Fig. 1 The orbits and trends in object labor productivity

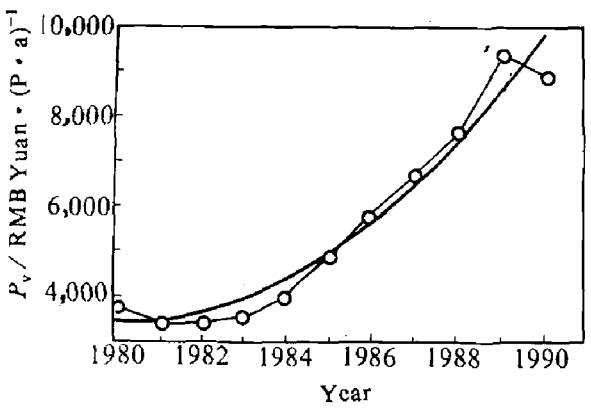

Fig. 2 The orbits and trends in value labor productivity

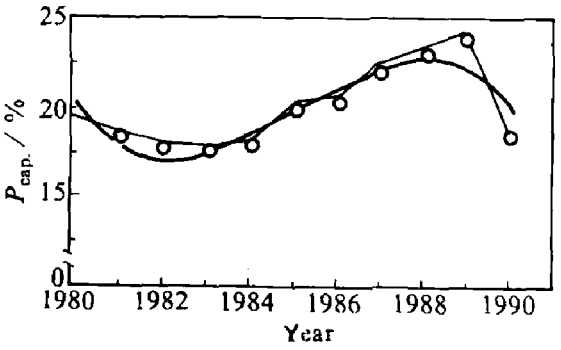

Fig. 3 The orbits and trends in capital labor productivity

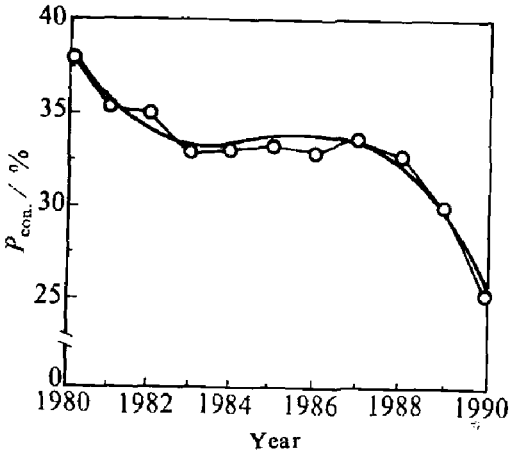

Fig. 4 The orbits and trends in material consumption productivity

resulted from a low capital increase in capital efficiency. During this period, management capital increased 31.7×10^8 RMB Yuan with a rate of increase 18.7%, while the net value of the output increased only 0.95×10^8 RMB Yuan with a rate of increase of 2.89 %. Meanwhile, production developed slowly and the capital utilization efficiency was low, in spite of the management capital increasing considerably. The increase in capital productivity (4.7%) in 1984～1989 was the result of increase in capital growth efficiency. During this period, the management capital increased 223.15×10^8 RMB Yuan with a rate of increase of 111%, while the net value of the output increased 65.58×10^8 RMB Yuan. This means the scale of production scale was enlarged; the output inereased rapidly; the invest- ment efficiency was good; and all these drama- tically improved the capital productivity. In 1990, capital productivity decreased drastically (by 5.49%), because the newly increased fixed assets were not fully used. The circulating capital, and in special the non-quota circulating capital were utilized too much and the circulative efficiency decreased (the circulation period was 170 d in 1989, and 233 d in 1990.

2. 2. 3 Material Consumption Productivity

During 1980～1990, material consumption productivity displayed no obvious periodic and irregular variation and, overally decreased considerably. Comparing 1990 with 1980, the output efficiency of material consumption decreased from 38.13% to 21.79%.

2. 2. 4 Value Productivity

During 1980～1990, the variation trends, range and rate of change value productivity were almost the same or similar to those of the M.C.P This indicates that the variation of the value productivity is mainly affected by the variation of the M.C.P, but not labour cost. And it can be explained why the M.C.P varies.

2. 3 *Conclusion of Synthetic Analysis*

2. 3. 1 The output and input, except employee (25.79%) increased largely. The growth of the value output, that is to say, the net value of the output (194.9%) was larger than that of metal output (91.78%); the growth of material labour input i.e. the growth of utilized management capital (208.87%) and material consumption (343.72%) were larger than that of output, especially the growth of material consumption.

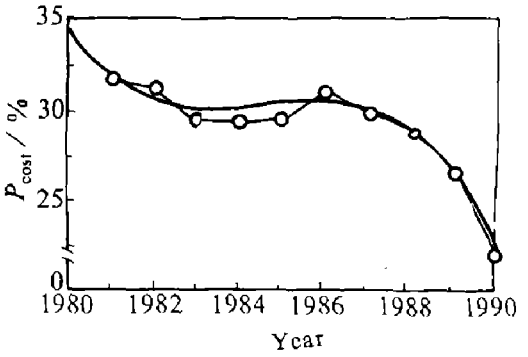

Fig. 5 The orbits and trends of value productivity

2. 3. 2 The level of labor productivity and its subindices increased greatly during 1981～1985, which was better than that of 1976～1980, while the levels of subindices increased much more during 1986～1990 than during 1981～1985. In special the magnitude of the increase in 1988 and 1989 reached a maximum and most of the indices also reached their best level. However there were still several important indices whose levels continually declined e.g., the net value of the output decreased by 7.3%; the M.C.P decreased by 12.66%. These are the main obstacles for improving productivity further. But there is also great potential to improve productivity in the future.

2. 3. 3 Increasing Volume of V.L.P The increase volume of value labour productivity almost depend on the increase of input structure indices (capital occupied per person, annual average material consumption per person). The

effect caused by the large increase in input structure indices is liable to hide the tremendous effect on the decrease of L.P resulting from the decrease in the output efficiency of the input factors.

2. 3. 4 The trend in the value labour productivity is similar to that of the M L.P. This means that the increase of the V.L.P. is based on the increase of the M.L.P.. In 1980 and 1990, M.L.P. is 1.432 and 2.184 t / p.a respectively, while the net values of the output per ton of metal was 2.639 and 4.090 RMB Yuan / t. The increase of the V.L.P resulting from the increase of the M.C.P. is 2.539 RMB Yuan / p, which is half the total increase of the V.L.P. The rest was caused by the increase in the net value of output of the metal.

2. 3. 5 The net value of the output per ton of metal was low, and was declining. From Table 1 one can see that, the net value of the output per ton of metal appears to have increased 54.57%. However, considering the variation in the material consumption per ton of metal (increased 131.38%) and in the average price per ton of metal (increased 110.18%), the net value of the output per ton of metal in fact decreased, because high tech products and other high additional value products decreased in quantity over those 10 years and are still decreasing. This is another important factor which obstructed the improvement of the productivity of the nonferrous metals industry, and a great potential to improve productivity lies therein.

3 IMPORTANT FACTORS RESTRICTING THE PRODUCTIVITY OF THE NONFERROUS METALS INDUSTRY

Considering the condition of the nonferrous metals industry, important factors restricting the productivity of the nonferrous metals industry are analysed as follows in terms of mineral resources, structures, quality and mechanisms.

3.1 *Mineral Resource Factors*

3. 1. 1 Poor Mineral Resources

Quite a lot of nonferrous ore deposits locate in regions of bad natural conditions making them difficult to exploit now. In most nonferrous metals mines, the environments for production are very bad, so the equipment abrasion and employees' labor consumption are high; communication is difficult; hydrogeological conditions are complicated; and relevant public facilities are insufficient. So the production input of labour, capital and materials in mines are higher than in other enterprises and so is the cost.

Mining productivity depends on ore deposit characteristics in defferent degrees. The technological and economical indices and productivity of open pit mines are higher than those of underground mines. However, the China National Nonferrous Metals Industry Corporation has only 15 open pit mines, which account for 45.3% of the total mines. This restricts the improvement of mining proctuctivity. Mineral resourses are a special factor influencing productivity in mines. The mieral resourse to be exploited diminishes with the amount of time, it is exploited and the production capacity finally vanishes. 58.5% mines were built in and before the 1950's according to statistical data on 82 mines. The labour input usually reaches a maximum for those mines which are in middle and late exploitation period. The increase of human labour and material labour per unit product and the reduction in net production act upon each other, thus making the productivity decrease drastically.

The influence of mineral resources as the productivity of the nonferrous metals industry demonstrate that production in the nonferrous metals indusstry is different from other industries and these factors restrict the improvement of the productivity of the nonferrous metals industry.

3. 1. 2 Low level of exploitation

In China, mineral resources are, in fact, free

input in mineral production, which has caused serious waste in mining and consumption. For example, the average ore grade of copper in China's mines is 0.67% now, while the average ore grade of copper in concentration plants is 0.81% which means mineral resources wasted by mining rich ores but giving up poor ores. The average actual recovery of copper in concentration plants was above 86% in 1949～1989. But it was only 81.83% in 1990.

In recent years, many nonferrous metals enterprises have worked hard on synthetic utilization of all kinds of intergrowing and associated valuable elements, and have emphasized increasing recovery so that contributions have been made in economic growth. For example, all fourteen kinds of valuable elements in the Jinchuan Nickel Mine can be recovered. In the concentration plant of the Jianxi Copper Corportion, gold, silver, molybdenum and sulphur can be synthetically recovered and the resulting benefits account for one quarter of the total sales income. But in China nonferrous mines the level of synthetically utilized valueable elements is still very low in general. According to uncompleted statistics, the associated valuable elements in China's nonferrous mines only 33 elements can be recovered. The recover capabilities in different mines vary considerably.

The synthetic management of "three wastes" is a very important problem for improving the environment. It is also one kind of synthetical utilization in a general sense. There are many examples in China nonferrous metals industry.

The degree of recovery and utilization wasted and miscellaneous nonferrous metals in China are much lower than those in other countries such as the USA and former USSR. In the USA, the regenerative aluminum is 26.4% of the original aluminum, while recovery of copper and Pb are 34% and 179.2% respectively. In the former USSR, zinc recovery is 13% of its original amount, and Sn recovery is 21.8%. However, the smelting capability for recovering wasted and miscellaneous nonferrous metals in China is only 293,000 tons which is 10.3% of the smelting capability of Al, Cu, Pb, Zn, Ni, Sn, Hg, Mg and Ti. Regenerative aluminum each year is less than 10,000 tons which accounts only 1.2% of its original product quantity.

3.1.3 Chaotic Management of Resource Exploitation

In recent years, a Chaotic situation existed in the management of mining nonferrous metals resources. Stimulated by some short term economic benifits, local governments, some collective and private owners set up many small mines, concentration plants, smelteries and factories. Many of them were repeatedly built. Mean while, a lot of private miners rushed into many state-owned mines, where they not only excavated ore but also stole and plundered mineral products and production installations. Unfortunately, the situation is still serious. In recent years, quite a number of mineral products of the local enterprises are purchased from the private owners, whose mining techniques usually serious wastemineral resources. The recovery of Sb from mining, processing and metallurgy is 78.7% in state-owned enterprises and 50% in local enterprises, but only 20%—30% in private enterprises, the average recovery of copper from mining and processing is 76.5% in state-owned enterprises and about 60% in local enterprises. The private dispose of 8 to 10 tons of original ore in order to obtain 1 ton of copper ore. The case is even more serious in wolframite mines. In some country-town and privately owned mines, the recovery through mining and processing is only 20—30%. According to the statisties from 10 wolframite mines in Jiangxi province, the annual waste of tungsten is over 10 thousand tons.

Our population is large and mineral resources are limited. Therefore, it is a strategic problem to develop, exploit and utilize mineral

resources reasonable and to save as much nonferrous metal as possible.

3.2 *Structure Factor*

3.2.1 Most enterprices have small production scales

A research of the economical production scale of electrolytie aluminum shows that (1) an economical scale for an electrolytic groove series whose current intensity is 60～75 kA, is 25～30 thousand tons, and (2) an economical scale for electrolytic groove series, whose current intensity is 160～180 kA, is 10 thousand tons. According to these standards, 52 small or middle scale factories have not yet reached proper scales of economy except for 10 aluminum factories whose production capacity is 42% of the whole. The situation in the copper, lead and zinc industries are similar to aluminum. This is an important reason for the low productuvity of the nonfer- rous metals industry. In addition, small scale enterprises cannot reduce production costs by taking advantage of technologies of scale, productivity of scale and operation scale, so their technology and economic indices are worse than large enterprises of the same type.

Nonferrous metals industrial production is suitable to continuous production. However, there are only 13 combined enterprises in the China National Nonferrous Metals Industry Corporation (CNNC) which consists of 157 enterprises: the rest of the CNNC, including 69 mines, 25 smelteries and 14 metal processing factories are not combined. This kind of individual organization is, in fact, a loose cooperative body, which is unfavourable to improve productivity. First, it's unfavourable to reduce costs, because the head of each factory is forced to put much of his or her attentions to administrative routines. Secondly, there are only a few combined enterprises, so the benefits of integrative are not good. Thirdly, independent enterprises on a small scale do not have ability to collect much capitals to exploit new technology.

3.2.2 Product Structure is Unfavourable for Improving Economical Profit

In 1990, China imported large quantities of copper and aluminum materials. But in the same period, much of China's processing ability was left unused. The surplus production ability and product structure which couldn't meet the nation's needs are in sharp contradiction. In the tungsten and molybdenum industries, how to improve quality, increase types of products, and deeply process are also important problems. In fact, the exploitation of new products for high profits has great effects on the improving productivity of the nonferrous metals industry. For example, in 1989, Shan Dong Aluminum Factory produced 10 thousand tons of a special type of aluminum oxide, and obtained almost 10 million RMB Yuan profit, which is much more than that of common aluminum oxide.

3.3 *Quality Factors*

3.3.1 A Large Portion of Obsolete Equipments

In general, the technological equipment of the nonferrous metals industry is obsolete. First, most equipment is old, while new equipment only account for one third in the whole industry and only 29.2% in state-owned enterprises. New equipments in the China National Nonferrous Metals Industry Corporation (C N N C) in the 1980's was even lower of 26.35%. The ratio between the net value of fixed assets and their original value (hereafter termed as coefficient of new degree) often used to judge whether an equipment is new or old. From this point of view, our equipments is seriously old. For example, the coefficient of new degree of the nonferrous metals industry only increased 1% from 1980 (65%) to 1990 (66%) while tolal investment increased

60%. By the end of 1990, there were 22 midde / large nonferrous metals enterprises accout for 40% of total enterprise number with a coefficient of new degree lower than 40%. Among other, some mines have a coefficient of 18%. Shen Yang Smelting Factory's coefficient is 38.7%. Northeast Light Alloy Processing Factory's coefficient is 38.4%; Fushun Aluminum Fac- tory's is 37%, and Dajishan Wolframite Mine only 7.3%.

It is universally accepted that equipment is one of the basic factors influecing productivity. More attention must be paid to equipment in order to improve the productivity of the nonferrous metals industry.

3. 3. 2 Employees' Quality Has to be Improved

Considering the structure of employees in the nonferrous metals industry, the portion of non-productive employees is too high. Workers account for 64.8% of the total numbers. This figure is 10.8% less than the national level, which means that non-productive employees occupies an unusually high portion of the tolal employees. The high portion of non-productive employees is the result of both present characteristics and management systems in the enterprises.

Analyzing the age structure of the employees, one can find that young employees, whose ages are below 35, accout for 59.3% of employees, which is 5.2% lower than the national average. As to the cultural level of education of the employees, 4.4% of them have had higher education, 22.6% have had primary education, and 4% are illiteratre. So modern equipments cannot be fully exploited.

The quality of employees is a decisive factor in productivity. Many problems existing in China's nonferrous metals industry, such as ineffective management, bad product quality, inefficiency and so on, are related to the quality of the employees. The improvement of employee quality is of great significance for raising productivity.

3. 4 *Mechanism Factor*

3. 4. 1 An Efficient Operation Mechanism Has not Formed

As an economic body, CNNC hasn't been operating independently.

First, the national production demand is too heavy. For example, in 1990 the instructed output of copper, aluminum, lead, zinc and tin accounted for 63.1% of their total output. Secondly, the prices of the products which were part of the instruct output were too low, which resulted in deficit in many enterprises. Thirdly, nonferrous metal products were centrally distributed by administration of goods and material, resulting in the production factories being unable to communicate directly with customers. This is the reason why some enterprises have not formed flexible operation mechanism and developed new products according to market demands.

3. 4. 2 The Current Contracting out System is not Perfect

Since 1984, the central government established fixed ratio financial contract with the CNNC. According to the operation conditions of various enterprises, CNNC concluded 8 different kinds of contracts with its subcorporations. Since 1986, the CNNC, has been directors (or managers) objectively responsible policies and connected their total salaries with benefits. The implementation of contracting policy has sped the development of production, and greatly raised profits and revenues. The government has also increased its financial income and left more profits for the enterprises. The incomes of employees have also increased. However, the current system is not perfect. For example, enterprises are hardly able to surmount their short

(*To be continued on page* № 94)

nace has an estimated volume of about 50 $m^3$and a daily production of 0.5 t pig iron. It is also noteworhty that limestone was used as flux and charcoal as fuel / reducing agent at the iron smelting. From the appearance of iron slag in glassy or massive form in the sites, it seemes that the slag had good fluidity. The composition of pig iron was C 4.0wt.−% ,Si 0.21wt.−% ,Mn 0.21wt.−% ,P 0.29wt.−% and S 0.091wt.−%.

3 CONCLUSIONS

The molten salt and slag in ancient China were an important part of copper smelting, bronze casting, bronze weapons manufacturing, iron smelting, glaze and glass making. This paper is a survey of ancient and present literature, and archaeological data. The author thinks that similar study should be carried further.

REFERENCES

1 Shen-Kuo(沈括) MengxiBitan(梦溪笔谈).in the years 1086～1093(the Song Dynasty).

2 Song-Yingxing(宋应星) Tiangong Kaiwu(天工开物). 1687(Ming Dynasty).

3 Li-Shizhen(李时珍) Bencao Gangmu(本草纲目).in the years 1552～1579(Ming Dynasty).

4 Beijing Iron and Steel Institute(ed.). A Brief History of Metallurgy in China. Beijing: Scientific Press 1976.

5 Hua, Jueming. The Technology of Metals in Ancient China. Beijing: Scientific and Technological Literature Press 1985.

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term behaviour according to the current contraction policy.The ratio of profits kept for enterprises decreased continuously which negatively affected their ability of capital accumulation and the development of enteaprises. All these factors have restricted productivity.

3. 4. 3 The Operation Mechanism of the Enterprise Has Defects

The operation Mechanism is a factor of productivity. In order to reform the inner operation mechanism of the enterprises, which is not proper for the improvement of productivity, the current labour system, personnal system and distribution system must be improved. During recent years, the CNNC established a series of necessary policies, such as connecting salaries with profits and revenues, assigning directors by an objective system, reducing the staff, etc.

All these reforms have had positive effects. However, there still exist many deep seated problems within the enterprises. Optimal mechanisms inside the enterprises should be built; the activity of employeers should be mobilized; and productivity should be improved efficiently.

(To be continued)