On the value chain and international specialization of China's pharmaceutical industry

Abstract: This article make the study of the character of medicine industry value chain and China's position in the world medicine industry value chain, using the tools of value chain analysis, GL index as well as input-output model. The research shows that proprietary medicine's value chain,which in the world medicine value chain, is totally belongs to the producer-driven type, and the core added value is mainly from the input of R&D; while in the non-proprietary medicine's value chain, the raw medicine is comparably independent and has a weak relation with the R& D link. This article is based on this reason and make a concrete study on China's position in the world medicine industry value chain, and the result shows that, China now stands at the lowest point of "smile curve" which is located at non-proprietary medicine production, demonstrating the vertical specialization division of the world medicine industry value chain, hereby work out the VS Index and local appreciation rate of Chinese medicine industry. In the end, the author analyse that China's position in R&D link of the world medicine value chain, and consider that Chinese cheaper labour cost is the main reason why multinational company move the clinical trail in China.

Key word: Value Chain Analysis, GL Index, Intra-industry trade, Vertical Specialization, Clinic trial

Part 1 Preface

Since China entering WTO, our medicine industry has experienced a rraw medicined progress. According to the statistics, the foreign trade volumes of Chinese medicine industry in 2008 has reached up to 12.28billion dollar, almost 2.6 times of the volume in 2002. Therefor, it is very important to use the modern value chain theory and international specialization theory to analyse our medicine industry's position in the world value chain and international specialization, and it plays a very important role in maintain a healthy and rraw medicined development of China's medicine industry.

This article make the study of the value chain of Chinese medicine industry and the status of international specialization under the frame of world value chain, there are six parts in this article, Part 2 is reference, illustrating the research background and the related methodology we used in this article. Part 3 is focused on the character of Medicine industry value chain; Part 4 is the ratified research on international specialization of world medicine industry; while Part 5 is the ratified study of the position of Chinese medicine industry in international specialization.Part 6 is conclusions.

Part 2 References

References on theory of Value chain

Value Chain was firstly put forward by Michael E.Porter in 1985.He deconstructed the production link as a series of value creattion, and thus the connection of this link is called Value Chain. Porter think that most of the Value Chain share the same character, which contains both production and supporting link, the former mainly contains production and marketing link in producing link, the latter mainly contains the related supporting link to the production link. E.g. Construction、R&D、Human Resources, etc.

Gereffi(1999) divides Value Chain into producer-driven and buyer-driven from the perspective of product character.. Kaplinsky and Morris(2000) further divide value chain into simple value chain and extended value chain. They pointed out that most of the value chain can be simplified as R&D.production,sales, consumption and the four link are interacted. While the detailed value chain is much more complicated than the mentioned above, normally related to several lines of business or industry, thus form a bigger value chain network. Gereffi(2005) further put forward the world value chain concept, which composing the entire R&D,design link of the upper course, spare parts manufacture and assembly of the middle course, as well as sales,,brand and service of the lower course into world production networking, providing a new perspective for analyzing every country's position in the international specialization under the world globalization.

References to International specialization

The earliest concept of international specialization can be traced back to Adam Smith's Absolute Advantage Theory , David Ricardo's Relative Advantage Theory, as well as Resource Endowment by Heckscher and Ohlin..

Since the latter of the last century, as long as the deepening development of international specialization, the share of intra-industry trade increased gradually and become the main stream of international specialization. Verdoom(1960) firstly put forward the phenomenon of increase of trade of the same product but not the different product under SITC. Balassa(1963) also proved the same viewpoint by research of EC.While Gray (1979)and Krugman(1981) also complete the concept of intra-industry trade. Grubel&Lloyd(1975) also put forward the concept of dividing intra-industry trade into horizontal and vertical trade , and already been adopted by most of the scholars.

In recent years, as long as the multinational company distribute various value chain link worldwide, vertical specialization becomes the new type of intra-industry division. Vertical Specialization refers to the international specialization in different production period in the same industry. This can be completed not only in in the multinational company but also in non-related company in different country by market regulation. VS index proposed by Hummels, Ishii and Yi （2001）provide condition for rationing division in vertical specialization. Now there are many scholars have conducted deep research and rationed measurement on every country's vertical specification status. This theory share the same theoretical base as the world value chain, and will gradually become one of the main stream of international specialization of every industry.

References on China's overrall value chain and international specialization

Till now, many scholars have studied the value chain and international specialization of china's overall or individual industry.: Liu Zunyi and Chen xikang(2007) had taken measurement and calculation on export's total value-added rate in 41 sectors using non-competitive input-output table. And the research team which is leaded by Ping xinqiao(2005) calculated the VS index in the

trade between China and USA.But because only the input-output table which include 123 sector can analyze the medicine industry, so there is no research on the TVA and VS index of medicine industry until now.

Part3　Study on medicine industry value chain structure

Particularity of medicine industry value chain

　　Kaplinsky and Morris(2000) make a conclusion on value chain structure and put forward that value chain can be divided into simple value chain and extended value chain. They maintain that most of the value chain can be described by four link model:R&D, production, sales and consumption. But the extended value chain of different product are more complicated, and they illustrate an extended value chain link chart taking the timber industry as an example.

　　According to the investigation results on six medical company such as Jin Ling Meical company in Jiangsu Province and the medicine production link which is issued on the website of Roche Company and Pfizer Company, we find that the simply value chain is similar to other finished product and agree with the model of Kaplinsky(2000), as illustrated in Figure 1.

Figure 1: Four links in a simple value chain
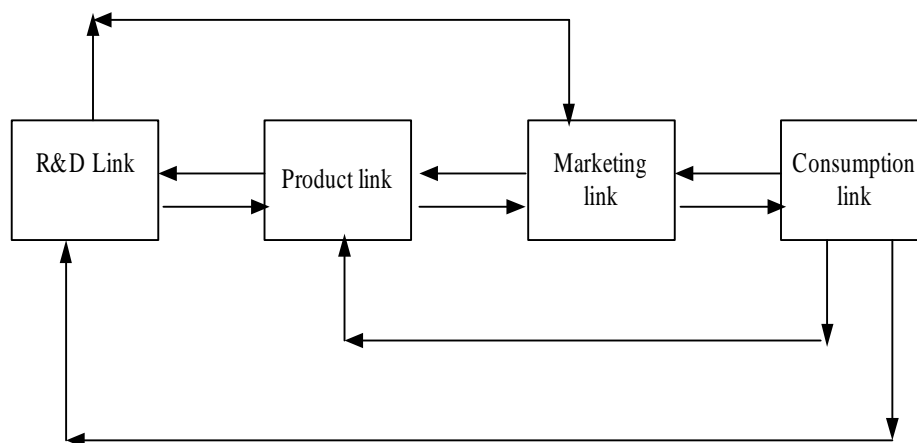
　　However, the extended value chain of the medicine has some very visible particularities, which can be shown as follows:

　　First, there exists clear difference between different medicine's value chain.And there are various catalogue of medicine worldwide, such as proprietary medicine and non-proprietary medicine, which is divided by standards of intellectual protection. In automobile and IT industry, different type of final products' production link share the high similarities .Though the above medicine are all final product, the production link's division shows visible inconsistency.

　　Second,Modularization degree of medicine's value chain is relatively low. Currently there are two modularization in the production link of medicine value chain, which is raw

medicine production and preparation production. The former is a chemical link, while the latter is a physical link.

Third, It is more complicated in R&D link of medicine industry, and modularization degree is comparably high. According to Pfizer company, The R&D link of oneproprietary medicine will undergo many link, for example, finding the ingredients,clinic trial development, new medicine clinic trial Phase I, II and III. Etc. So after many years of clinic trial, this new medicine will not have the access to the market if no many years of clinic trial.

There are different character in different R&D link in medicine industry, clinic trial is the most representative.In above link, the clinic trial is the core link in medicine industry, and also very special link. The main function of this link is to put the trial medicine from the former R&D link into human body, according a certain rules, and give the feedback to the former R&D link. Therefor, this link require not only high-tech talents, but also need to recruit large amount of patients to attend this trial, thus greatly increase the cost of the entire R&D link.

Study of Extended value chain ofproprietary medicine and non-proprietary medicine

But the extended value chain in propreitary medicine and non-propreitary medicine is different. Figure 2 shows the extended value chain of proprietary medicine production. You can see there is a very long period of R&D link in proprietary medicine, which is a very indispensable link for the follow-up link. It result in such characteristics of proprietary madicine production as high risk, high input and high value-added rate. According to PHRMA's statistics, R&D input of every proprietary medicine in 2006 demand for 1.3 billion dollars. Such high input determined that R&D and production link of proprietary medicine is monopolized by multinational company.

Based on the above analysis, We make an judgement on the added value of various value chain of the proprietary medicine/ Firstly, R&D link is the main value-added link in proprietary medicine value chain, ensuring the position of patent owner's monopoly right. Secondly, the former two sub link in the R&D link are the main value added link, while clinic trial only assistant link which providing data support to the former two link. Thirdly, the production link actually also the auxiliary link to the R&D link, functioning as realizing profit. Finally, Due to almost complete monopoly of the multinational company, the added value from marketing link is far lower than R&D link.

Figure 2: the extended value chain of the proprietary medicine

```
┌─────────────────┐
│ Develop the main│
│ component(raw   │
│ medicine)       │
└─────────────────┘
        │        failed
        ▼
┌─────────────────┐
│ R&D  before     │
│ clinic(preparation) │
└─────────────────┘
        │        Not permited
        ▼
┌─────────────────┐
│ Clinical trial I│
└─────────────────┘
        │
        ▼
┌─────────────────┐
│ Clinical trial II│
└─────────────────┘
        │
        ▼
┌─────────────────┐
│ Clinical trial III│
└─────────────────┘
```

Failed

consumption

┌──────────────┐   ┌──────────────┐   ┌──────────────┐
│ Taw material │   │ Preparation │   │ Marketing   │
│ production   │   │ production   │   │   │
└──────────────┘   └──────────────┘   └──────────────┘
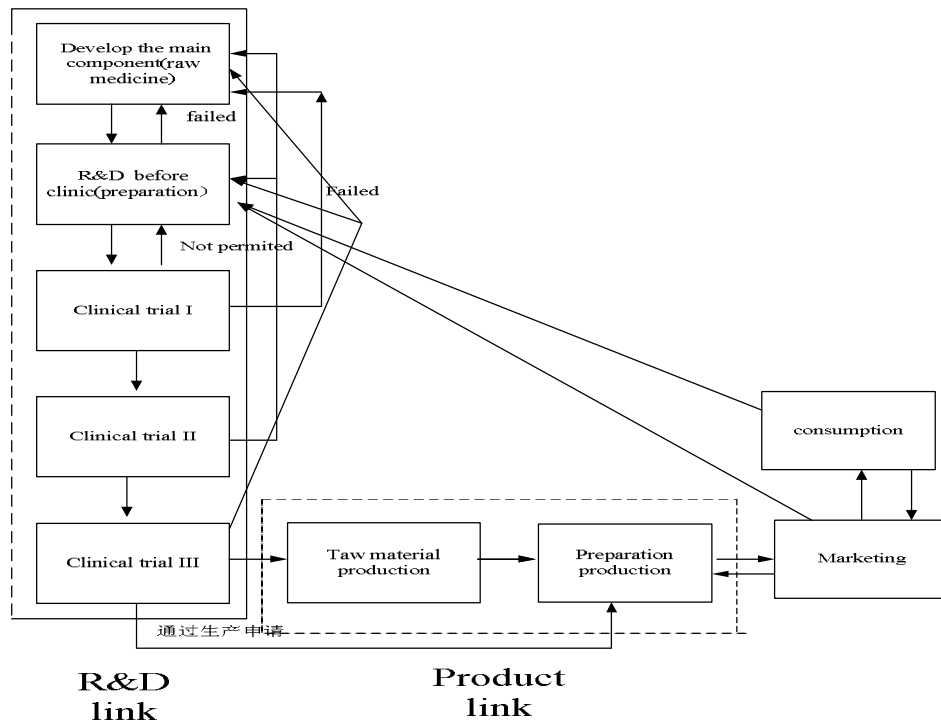
通过生产申请

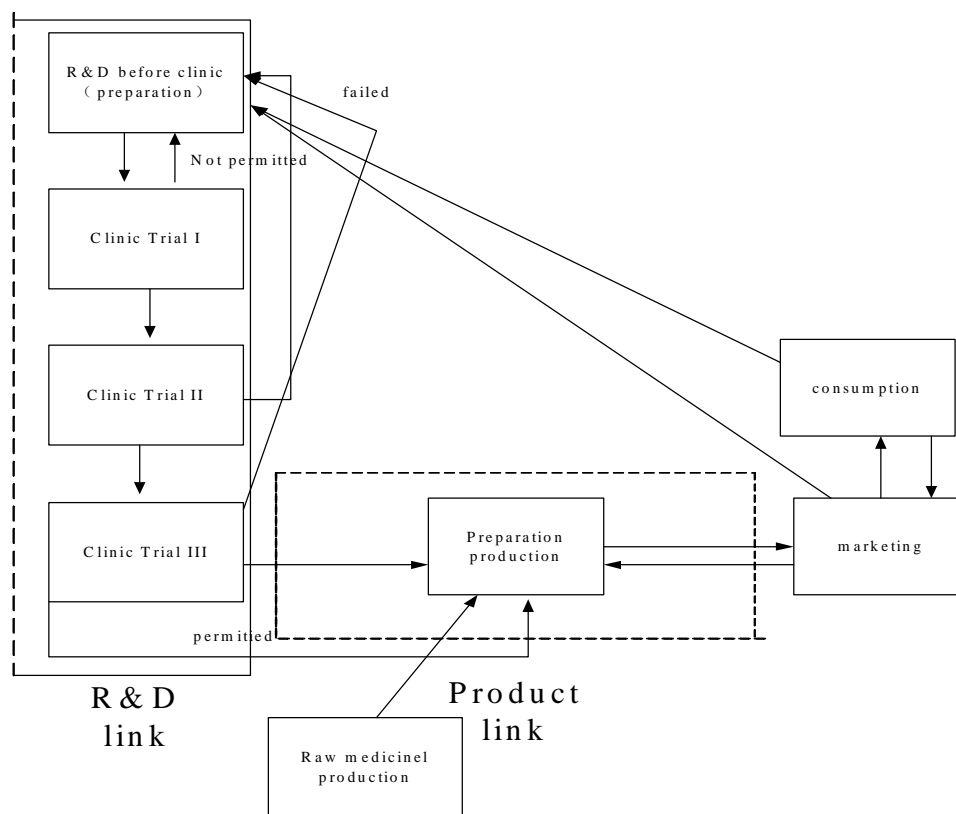**R&D link**   **Product link**

Figure 3 shows the non-proprietary medicine's extended value chain. Compared with Figure 2 and Figure 3, non-proprietary medicine's value chain has the differences fromproprietary medicine as follows:

Figure 3: the extended value chain of the non-proprietary medicine

```
┌─────────────────────────┐
│  R & D before clinic    │         failed
│  （preparation）         │
└─────────────────────────┘
        │    ↑  Not permitted
        ↓    │
┌─────────────────────────┐
│  Clinic Trial I         │
└─────────────────────────┘
        │
        ↓
┌─────────────────────────┐
│  Clinic Trial II        │                              ┌──────────────┐
└─────────────────────────┘                              │ consumption  │
        │                                                └──────────────┘
        ↓                         ┌──────────────┐            ↑    ↓
┌─────────────────────────┐       │ Preparation  │        ┌──────────────┐
│  Clinic Trial III       │ ────→ │ production    │ ←───→  │  marketing   │
└─────────────────────────┘       └──────────────┘        └──────────────┘
          permitted                     ↑    ↑
   R & D                         ┌──────────────┐   Product
   link                          │ Raw medicinel │    link
                                 │ production    │
                                 └──────────────┘
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First, The total value added ratio of non-proprietary medicine is clearly lower than proprietary medicine. The reason is that non-proprietary medicine has no link of finding components compared to proprietary medicine, while this link is just located on the upper left top of "smile curve", and that is the maximum value added link. Thus the value added ratio of non-proprietary medicine is clearly lower thanproprietary medicine.

Second, non-proprietary medicine production is the link which is called R&D before clinic, and also the main value added link. From Chart 4, we can see that the production of raw medicine for non-proprietary medicine is out of the main value chain,and has no clear relation with the former R&D link, while the non-proprietary medicine pharmaceutical production has a direct connection with R&D link. In fact, some non-proprietary medicine's pharmaceutical formulation is the same as that of the proprietary medicine, so there is also no the second sub link of the R&D link in their value chain.

Second, there is more competition in non-proprietary medicine market than proprietary medicine market, thus adding more value to the marketing link. Due to lower threshold of non-proprietary medicine than proprietary medicine, non-proprietary medicine production are not limited to fewer multinational companies, but also widely seen in most companies in developed countries, even some middle to small sized pharmaceutical manufactures in developing countries,thus more degree of competition than proprietary medicine. The above market structure increase the value added ratio of marketing link.

 Last, The degree of non-proprietary medicine production competition is the utmost. For most of the medicine, the threshold of raw medicine production lie in its production technology. When the production technology is publicized, the threshold of non-proprietary medicine's raw

medicine is far lower than non-proprietary medicine preparation manufacture, which has a strongest competitive edge than others.Due to the alternative character of raw medicine among many companies, the value added ratio of this link is the lowest and it is very easy to have low price competition.

Based on above, This article make an judgement on the characteristics of proprietary medicine and non-proprietary medicine's value chain according to Gereffi's method (1999). Gereffi hold that value chain can be judged by the system in Table 1.

Table 1:   Producer-driven and Buyer-Driven value chains

	Producer-Driven Commodity Chains	Buyer-Driven Commodity Chains
Drivers of Global Commodity Chains	Industrial Craw medicinetal	Commercial Craw medicinetal
Core Competencies	R&D;Production	Marketing;Design
Barriers	Economies of Scale	Economies of Scope
Typical Industries	Automobiles; Computers; Aircraft	Apparel;Footwear; Toys
Ownership of Manufacturing Firms	Transnational Firms	Local Firms, predominantly in developing countries
Main Network Links	Investment-based	Trade-based

Source: Gereffi,1999b.

According to the above analysis, we can make an judgement on the value chain ofproprietary medicine, non-proprietary medicine   raw medicine and non-proprietary medicine pharmaceutical preparation.proprietary medicine's core competition edge is mainly in R&D,and have a high demand of investment and technical input which mainly manipulated by multinational company. Therefor belongs to producer-driven; while marketing link and production link have clearly upgrade the core competition edge on non-proprietary medicine pharmaceutical preparation, which are attended by multinational company and local middle to small sized company, thus shares both character of producer-driven and buyer-driven; Non-proprietary medicine raw medicine mainly come from marketing link and it has a very low threshold, therefor local company have a higher proportion, and belongs to buyer-driven value chain.

Analysis on character of Chinese medicine industry value chain

Chinese medicine industry has two important characters:

First, Our medicine industry has a high dispersion degree, no multinational company is existing. According to Chinese High-Tech Statistic Yearbook, the article give an calculation of the proportion   of Chinese Multinational company's added value on whole industry's added value. The calculation shows that the proportion is 22..3% in 2007. According to the statistics   released by US creation new medicine committee, 30 biggest multinational company's sales volume is up to 76.9% of it total medicine sales.This demonstrate that our medicine industry is actually led by small to middle sized company while no multinational company existing in China.

Second, The R&D input in Chinese medicine industry is low, on one side, our medicine industry's R&D input scale is very low. According to statistics, the input of science activities in medicine industry is up to 6.3billion yuan in 2007.while Phifzer company had input 8.7 billion dollar in R&D in 2008. On the other side, our medicine industry's R&D indensity is low, the following table shows the differences in R&D indensity between our country and developed countries in pharmaceutical manufacture.

Table 2: The comparation of the R&D indensity in China and some developed countries

	China	USA	Japan	Germany	France	England	Korea
	2007	2006	2006	2006	2006	2006	2006
Manufacture	3.5	10.2	11	7.6	9.9	7	9.3
High-tech industry	6	39.8	28.9	21.5	31.9	26.6	21.3
medical industry	4.7	46.2	37.1	23.9	33.4	42.3	6.3

Source: ministry of Science and Technology of the People's Republic of China

We can see that the R&D indensity of Chinese medicine manufacture is just little bit higher than the average level of manufacture industry, which is not only far lower than developed countries,but also lower than the average level of Chinese high-tech industry, Thus, R&D link is not the leading place in medicine manufacture industry.

Based on the above character and the above theories, we can conclude that our medicine industry's value chain is buyer-driven.

Part4   Empirical research on international specialization of World medicine industry

According to the analysis of world medicine industry value chain,we can make the assumption of international specialization status of world medicine industry:

Assumption 1: the intra-industry division in developed countries are the main type of international specialization of   world medicine industry.

Therefor, we can predict that the medicine, especially final product value chain has a typical character of technology intensive, while no labour intensive link there. Developed countries have a very visible advantage in high tech field than developing countries, Thus, we can predict that the intra-industry division among developed countries is the main type of world medicine industry division.

The article give the calculation of world medicine trade breakdown by countries. Related data are from United States Commodity Trade Database and the statistical standards are shown in Appendix I. According to the above statistical standards, the article give an calculation on the distribution of world medicine trade and the result is in Table 3.

Table 3: the distribution of world medicine trade

	Proportion of Export	Proportion of Import
	2008	2008
Developed Countries:	90.55%	80.15%
EU15 and Switzerland	80.02%	56.85%
USA	7.98%	15.73%
Canada	1.53%	2.84%
Australia	0.86%	1.84%
Japan	0.89%	2.90%
Other Countries:	9.45%	19.85%
India	1.51%	0.53%
China	1.81%	1.45%

Source: calculated by the data from U.N. commodity trade statistics.

The result show that most of the world medicine trade are operated among developed countries,about 91 precent of medicine export and 80 percent of the medicine import supply are in 20 developed countries. Developing countries like China and India, though quicken their steps in international specialization of world medicine, occupy very small portion of world medicine trade.

On this base, the article gives us an judgement of how developed countries conduct international specialization in medicine industry, using GL Index   by Grubel&Lloyd(1975).

The GL index is defiinited as follows:

$$GL_j = \frac{\sum_{i=1}^{N}(X_i + M_i) - \sum_{i=1}^{N}(|X_i - M_i|)}{\sum_{i=1}^{N}(X_i + M_i)} \times 100$$

X_i,export of the i product; M_i,import of the i product

According to the statistics of the medicine product, the article calculate the GL index of medicine product, raw medicine of US, UK, Switzerland, France and German in 2004 and 2008. The result is in table 4. It shows that every countries' GL index is over 0.5 and is in obvious rising trend. This proves that the intra-industry division in developed countries are the main type of international specialization of world medicine industry. From the perspective of product structure, we can see that the GL index of raw medicine as intermediate product is comparatively low, while the GL index of main trade product--pharmaceutical preparation is comparatively high.

Table4:   The GL index of medicial trade in five developed country

	Year	GL index of the total medical trade	GL index of the raw medicine	GL index of the preparation trade

France	2004	73.25	48.98	76.78
	2008	78.54	60.77	80.19
Germany	2004	59.2	57.8	59.33
	2008	61.34	40.41	63.08
Switzerland	2004	66.87	46.66	70.03
	2008	57.26	51.7	57.82
England	2004	77.97	57.48	79.36
	2008	75.8	80.06	75.6
USA	2004	69.58	77.66	67.96
	2008	63	65.91	62.51

Source: calculated by the data from U.N. commodity trade statistics.

Assumption2: The final product trading is the main type of world medicine trade, the intermediate product occupies smaller proportion. International trade theory shows that the trading of intermediate product greatly rely on two points: first, the separability when producing in space; second, different factor endowment in different producing link. We can speculate that the separability degree of producing link inpropriety medicine which are dominant in world market share is weak, thus the final product trade will be the dominant type of the world medicine product division.

The following paragraph will positive study the result. According to analysis above, we take raw medicine as intermediate product in world medicine industry, while take all kinds of preparations as final product. Appendix 1 shows the statistic standard of the calculation.

Based on that, the article calculate separately the ratio of consuming product and intermediate product in world medicine trade in 2008, shown in following table. The result demonstrate that Assumption 2 is correct, and the international specialization is mainly conducted by final product trade.

Table 5:   the proportion of the intermediate product trade and the final product trade

	preparation trade(2008) (intermediate product)	Raw medicine trade(2008) (final product)
proportion of export	90.40%	9.60%
proportion of import	90.59%	9.41%

Source: calculated by the data from U.N. commodity trade statistics.

Assumption3: most of the trade between the develped countries is horizontal intra-industry trade. Intra-industry trade can be divided in two parts: horizontal intra-industry trade(HIIT) and vertical intra-industry trade(VIIT). HIIT means the technological level of import and export is similar, while VIIT means the technological level is different. Fukao&Ishido(2004)gives the criteria to judge whether the trade is HIIT or VIIT. The method is as follows:

$$\frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \leq 0.1; \quad \texttt{unilateral trade;}$$

$$\mathbf{0.1} \leq \frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \leq 10 \text{且} \mathbf{0.8} \leq \frac{P_{kk'j}}{P_{k'kj}} \leq 1.25 \text{时}, \quad \texttt{horizontal inter-industry trade;}$$

$$\mathbf{0.1} \leq \frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \leq 10 \text{且} \mathbf{0.8} \leq \frac{P_{kk'j}}{P_{k'kj}} \geq 1.25 \text{或} \frac{P_{kk'j}}{P_{k'kj}} \leq 0.8 \text{时}, \quad \texttt{vertical inter-industry trade}$$

$M_{kk'j}$: **country k export to country k' in commodity j**, $P_{kk'j}$: **the price, 0.1、1.25 and 0.8为threshold**

Based on that, the article calculate separately the proportiong of unilateral trade, HIIT and VIIT in the trade between France, Germany and USA, shown in following table. The result demonstrate that Assumption 3 is correct,

Table 6: the proportion of unliateral trade,VIIT and HIIT

	proportion of unilateral trade(2008)	proportion of vertical intra-industry trade(2008)	proportion of horizontal intra-industry trade(2008)
Germany and USA	20.89%	30.11%	49.01%
France and USA	16.28%	10.97%	72.75%

Source: calculated by the data from U.N. commodity trade statistics.

Part5　Empirical Study on Chinese Medicine Industry Division

Medicine industry value chain is relatively simple in production link, and is divided into raw medicine production and preparation production. We can judge the position of Chinese Medicine industry in the international specialization according to Trade Special Coefficient of Chinese RAW MEDICINE and Preparation.

The article gives an calculation on Chinese and Indian medicine product, RAW MEDICINE and Preparation's Trade Special Coefficient since 2004, as shown in table 8&9.

We can see from the chart that China and India both have a certain degree of overall competitiveness in medicine industry, but the origin of the competitiveness differs greatly. In the respects of raw medicine, Chinese TC index is very high, near to the absolute comparative advantage position; while India locate at a relative low position. In the preparation field, China locates low position and TC index has a falling trend; while India has an remarkable advantage. Thus we can infer that since 2004, In the world medicine value chain production link, China is mainly positioned on RAW MEDICINE producing link while India locates in Preparation link.

Table 8: the TC index of China and India medicine trade

Year	TC index of China	TC index of India

2004	0.19	0.55
2005	0.17	0.5
2006	0.17	0.49
2007	0.15	0.47
2008	0.13	0.52

Source: calculated by the data from U.N. commodity trade statistics and China customs.

Table 9: the TC index of China and India intermediate product trade and prepraation product trade

Year	Intermediate products		Preparation products	
	TC index of China	TC index of India	TC index of China	TC index of India
2004	0.73	-0.01	-0.56	0.76
2005	0.74	-0.11	-0.56	0.74
2006	0.78	-0.15	-0.58	0.7
2007	0.79	-0.13	-0.58	0.7
2008	0.8	-0.06	-0.6	0.71

Source: calculated by the data from U.N. commodity trade statistics and China customs.

We can get the same conclusion using intra-industry trade analysis method. table 10 and 11 give an calculation on GL index of China and India in 2004-2008 as well as both countries' bilateral trade, vertical inner trade and horizontal trade ratio in medicine trade.

Table 10: the GL index of China and India medicine trade

Year	GL index of China	GL index of India
2004	34.45	38.26
2005	33.76	39.1
2006	31.16	40.04
2007	30.62	42.4
2008	29.32	40.11

Source: calculated by the data from U.N. commodity trade statistics and China customs.

Table 11: the proportion of unilateral trade, VIIT and HIIT in China and India

		Unilateral trade(import)	Unilateral trade(export)	VIIT	HIIT
China	Total medical trade	34.03%	53.12%	12.85%	0.00%
	Preparation trade	87.95%	0.00%	12.05%	0.00%

	raw medicine trade	0.00%	85.92%	14.08%	0.00%
India	Total medical trade	8.96%	0.00%	89.86%	1.18%
	Preparation trade	0.00%	0.00%	95.19%	4.81%
	raw medicine trade	0.00%	12.74%	87.26%	0.00%

Source: calculated by the data from U.N. commodity trade statistics and China customs.

Thus we can see, The degree of intra-industry trade of Indian foreign trade on medicine product is obviously higher than China, and closer to developed countries in Europe and United States.; We can also see from the method of Fukao&Ishido(2003) that China's raw medicine is on bilateral export status, while the leading industry--Preparations are basically on import status and not attending the intra-industry division;India basically on vertical intra-industry trade both in raw medicine and Preparations, and the degree of attending the intra-industry division is much more higher than China.

China's statue of raw medicine in world medicine value chain is not a good sign for the development of our medicine industry. As described above, in non-proprietary medicine field, raw medicine production has a weak connection with core link of value chain---R&D link, while Preparation production has a closer connection with R&D link, Thus raw medicine production is the lowest end link in non-proprietary medicine value chain. While R&D and production in Preparations are the relative high end. So we can regard China's position in international specialization of its non-proprietary medicine is on the lowest end of "smile curve", while India located on a relative high end of it.

Because the raw medicine production is one of the link of final product of Preparations, our country has the characteristics of vertical specialization when attending the international specialization of world medicine industry. Vertical specialization refers to the international specialization of different production link of the same product in same industry, a new type of vertical industry division, and also the main type of intra-industry division between developed countries and developing country, Clearly, raw medicine production in China embodies the higher efficiency by multinational company's vertical specialization.

But there is great difference between vertical specialization of medicine industry and IT industry. On the one hand, though there is weak connection between raw medicine production and core R&D link, raw medicine production still belongs to craw medicinetal intensive industry link, and have higher requirements on technical and craw medicinetal than assembly link of IT industry. Therefor, though China is now located on the lowest end on world medicine value chain, but the added value is much higher than the assembly link of IT industry. On the other hand, the assembly link of IT industry is located at the end of its value chain, and the product are directly for sales. While raw medicine is located at the front part of production chain in medicine value chain, if outsourcing this part can lower down the cost in some degree, it will produce more uncertainty for the latter high value added link, and may enlarge the production risk. Thus, the degree of vertical specialization of Chinese medicine industry maybe far lower than hthe IT industry. At last, the relation of the vertical specialization and processing trade is weaker than the manufacture industry

like IT industry.

We used the Input-Holding-Output Model of the Non-Competitive Imports Type Capturing China's Processing Exports by Chen Xikang and Zhu Kunfu(2008) to calculate the VS index and domestic value-added ratio. With their help, we constructed the Input-Holding –Output Models which includes 43 sectors in 2002. This process used the 42 sector input-Holding –Output Models ,the 123 sector Input-Holding-Output Models, and the processing trade of Chinese medicine. All the data is in 2002.

So we can caluculate the VS index and domestic value-added ratio by the method in Chen Xikang and Zhukunfu(2008). The result is in table 12 and table 13.

Table 12: the VS index in medicine industry in 2002

	Direct VS index			Total VS Index		
	General Trade	Processing Trade	Total	General Trade	Processing Trade	Total
Manufacture of food products and tobacco processing	0.0013	0.5075	0.1115	0.0081	0.5664	0.19
Textile goods	0.0025	0.6389	0.1991	0.0124	0.6977	0.273
Wearing apparel, leather, furs, down and related products	0.0022	0.5929	0.198	0.0113	0.6616	0.2829
Sawmills and furniture	0.0025	0.5831	0.1798	0.013	0.6514	0.3175
Paper and products, printing and record medium reproduction	0.003	0.5399	0.2059	0.0127	0.6147	0.341
Petroleum processing, coking and nuclear fuel processing	0.0546	0.7302	0.684	0.0705	0.7755	0.7326
Chemicals	**0.0071**	**0.6416**	**0.3592**	**0.0237**	**0.7267**	**0.5303**
Medicine industry	**0.0042**	**0.5253**	**0.2732**	**0.0129**	**0.5937**	**0.3816**
Nonmetal mineral products	0.0045	0.5512	0.2482	0.0175	0.628	0.3962
Metals smelting and pressing	0.0061	0.6917	0.281	0.0224	0.737	0.4715
Metal products	0.0034	0.7382	0.2323	0.0189	0.776	0.4589
Common and special equipment	0.0072	0.6944	0.3709	0.0213	0.7466	0.5284
Transport equipment	0.0066	0.6905	0.3257	0.0214	0.7552	0.5369
Electric equipment and machinery	0.0079	0.7239	0.3443	0.0227	0.7723	0.5189
Telecommunication equipment, computer and other electronic equipment	**0.0058**	**0.8221**	**0.5112**	**0.0201**	**0.8419**	**0.621**
Instruments, meters, cultural and office machinery	0.0489	0.6062	0.3626	0.0629	0.6408	0.5103

Table 13: the domestic value-added ratio in medicine industry in 2002

	DVA			TVA		
	General Trade	Processing Trade	Total	General Trade	Processing Trade	Total
Manufacture of food products and tobacco processing	0.3403	0.1701	0.2132	0.9919	0.4336	0.81
Textile goods	0.2896	0.1357	0.1761	0.9876	0.3023	0.727
Wearing apparel, leather, furs, down and related products	0.3233	0.1346	0.1857	0.9887	0.3384	0.7171
Sawmills and furniture	0.3148	0.1494	0.1923	0.987	0.3486	0.6825
Paper and products, printing and record medium reproduction	0.3772	0.1843	0.2409	0.9873	0.3853	0.659
Petroleum processing, coking and nuclear fuel processing	0.1835	0.0942	0.1177	0.9295	0.2245	0.2674
Chemicals	**0.2754**	**0.1355**	**0.1735**	**0.9763**	**0.2733**	**0.4697**
Medicine industry	**0.4148**	**0.2397**	**0.2827**	**0.9871**	**0.4063**	**0.6184**
Nonmetal mineral products	0.355	0.1801	0.2254	0.9825	0.372	0.6038
Metals smelting and pressing	0.2596	0.1336	0.1671	0.9776	0.263	0.5285
Metal products	0.2665	0.1296	0.1678	0.9811	0.224	0.5411
Common and special equipment	0.314	0.1538	0.1948	0.9787	0.2534	0.4716
Transport equipment	0.288	0.1436	0.1815	0.9786	0.2448	0.4631
Electric equipment and machinery	0.2817	0.1322	0.1818	0.9773	0.2277	0.4811
Telecommunication equipment, computer and other electronic equipment	**0.2655**	**0.1151**	**0.1749**	**0.9799**	**0.1581**	**0.379**
Instruments, meters, cultural and office machinery	0.1883	0.2888	0.0891	0.9371	0.3592	0.4897

The result proves our assumption is right. TVS value of our medicine industry is 0.38, the processing trade's TVS value is 0.59, just higher than some light industry like food and textile, and far lower than IT industry and transport equipment industry. Therefore, the domestic value added of Chinese medicine production is very high, which has reach to 0.618 in regarding to its domestic value added ratio, this shows that exporting 1000dollars medicine product can bring us 618 dollar domestic value added earning, 1.63 times of communication equipment, computer and other electronics equipment. All this demonstrate that the local added value of domestic medicine industry is much higher than IT industry though ithey both locate at the lowest end of the value chain.

Other data can also support this conclusion. The main indirect proof comes from the processing trade statue of our medicine industry. The main way of attending vertical specialization

is by linking trade. But the position of linking trade is comparatively low in foreign trade. According to the statistics provided by United States International Trade Commission,this article compares the ratio of linking trade with general trade export between China and US, the result is as follows:

Table 14: the Proportion of General trade and Processing trade between China and US in medicine industry

		2006	2007	2008
Total	Proportion of General trade	81.95%	87.42%	81.09%
	Proportion of Processing trade	11.25%	11.64%	16.60%
Raw medicine	Proportion of General trade	81.45%	87.11%	80.93%
	Proportion of Processing trade	18.02%	12.08%	16.81%
Preparation	Proportion of General trade	98.53%	95.07%	82.77%
	Proportion of Processing trade	0.53%	0.52%	14.32%

Source: calculated by the data from China customs.

We can see that the export ratio of linking trade of medicine industry is floating around 15%,far lower than the average level of linking trade export.

Another proof comes from the company structure of our medicine export. Multinational company occupies less ratio in Chinese medicine export than IT industry. It is estimated that only 33.1% of the export medicine to US are operated by foreign invested company, others are all local company. Even in linking trade, Chinese local company take a advantage position. In 2008, Chinese local company's export to US in medicine linking trade is up to 68% . The proportion of Foreign invested company is over 80% in overall linking trade export.

This result shows that our medicine industry, though attending world vertical specialization in some degree, is not led by foreign invested company, and it is the result of local company's seeking to maximize the benefits and actively attending the international specialization.

The above article mainly analyse the position in world medicine industry value chain. In R&D link, multinational company has the intention to move the clinic trial to China. As described above,The R&D trial link is different from the former two link, which need not only high tech talents but also large amount of craw medicinetal.to get the experiment data from all kinds of experiment. Therefore, our country has a relative advantage in clinic trial. On the one hand, because the clinic trial cost is much higher in developed countries than China due to their high resident income; on the other hand,Clinic trial's function is mainly offering database support, thus the technical spillovers effect is far lower than the other link and give less influence on multinational country's technical monopoly .

In order to give evidence to this conclusion, we do some statistics on multinational company's clinic trial and pharmaceutical company's data based on the biggest clinic trial registered database"clinicaltrials.gov" and the data from China's High-tech Statistical Yearbook, shown in table 16. The result shows that in 2007 multinational company's clinic trial in China increase 74% of that in 2005. Higher than the ratio of value added 57% of the same period.

Table 16: Clinic trials in China

Year	Clinic trial number by TNE	TNE number	Value-added by TNE (100 MRMB)

	2005	79	707	364.05
	2006	123	739	432.9
	2007	137	797	570.12

Due to the increasing demand for clinic trial candidates for I -II(from tens of candidates in Phase I to thousands in Phase IV), therefore, In Phase III&Phase IV, more expenditures on collecting sample data in clinic trial cost than the former link, Thus, we can prove the cost advantage in Chinese clinic trial by analysing the structure of multinational company's clinic trial in China. The result is in table 17.

Table 17: Clinic trials I-IV in China and Total world by TNEs

Year	TNE in China				TNE in total Wrold			
	Phase I	Phase II	Phase III	Phase IV	Phase I	Phase II	Phase III	Phase IV
2005	2.56%	16.67%	55.13%	25.64%	8.66%	32.14%	38.78%	20.41%
2006	5.79%	9.92%	69.42%	14.88%	15.04%	32.52%	34.68%	17.76%
2007	5.69%	17.89%	55.28%	21.14%	20.46%	35.33%	27.59%	16.61%
2008	8.21%	9.70%	53.73%	28.36%	25.07%	32.77%	25.94%	16.22%

Thus we can see that in clinic trial in China by multinational company, the labour cost proportions higher in Phase III&IV than average level. We can conclude that the main reason for conducting clinical trail in China is because we have a lower labour cost.

Part6　Conclusion

On the analysis of medicine industry value chain, we can have an empirical study on Chinese medicine industry position in international specialization and make the conclusion as follows:

First, Comparing to other manufacture business, medicine industry value chain has the character of complicated R&D link, lower modularizationdegree of production link, and these characters makes the main type of medicine industry division is the horizontal intra-industry division among developed countries.

Second, .proprietary medicine and non-proprietary medicine has clear differences in their value chain. The modularizationdegree of non patent chemicals Preparations value chain is higher thanproprietary medicine, and Nonproprietary medicine has less demand for R&D in RAW MEDICINE medicine production link , which makes the medicine industry has some degree of vertical specialization.

Third, The unique clinic trial in R&D link in medicine industry have the character of strong modular, technical spillovers lower, greater portion of labour intensive,which makes outsourcing becomes the main type of vertical specialization in R&D link. Experimental results show that the lower cost of clinic trial make the multinational company intend to transfer the clinic trial to China

Fourth,The character of lower degree of R&D, small scaled enterprises determined that China mainly attend vertical specialization in non-proprietary medicine RAW MEDICINE medicine production, and less active than IT industry, This link is the lowest end of world value chain in medicine product.

Last, VS index and vertical specialization ratio shows that linking trade is dominant by local company, due to it low level of vertical specialization. Though medicine industry and IT industry are both in the lowest end of value chain, the local value added ratio of medicine industry is higher

than IT industry.

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Appendix I : Statistical standards of Various medicine product

Nowadays there is still no agreement on statistical standards of various medicine's foreign trade. In respective of the limit of data, this article do some data statistic on global medicine trade by the rules as follows: in HS product code 2935,2936,2937,2939,2941 and 3001-3004, 2935-2941 covers 95% chemical RAW MEDICINE medicine; 3003-3004 covers almost all the chemical Preparations,Plant preparations, chinese medicine preparations and part of Bio preparations, This article does not list the general medical supplies like bandage, medical splint and medical box into preparations product category.