Structural Bonus of Factor Productivity in China's High-Tech Industry: A Cross-Sector, Cross-Province, and Cross-Ownership Study

Liu Peigang
Central University of Finance and Economics of China

Ann Rensel
Niagara University

Tenpao Lee
Niagara University

Mao Pei
Central University of Finance and Economics of China

The evolution of Chinese high-tech industry labor force and capital structure is analyzed using a shift-share technique. Contributions from cross-sector, cross-province and cross-ownership flows of factors to productivity growth were assessed. Cross-sector labor force flow produced "positive structural bonus", cross-sector capital flow produced "negative structural bonus", cross-province labor flow produced "negative structural bonus", cross-province capital flow produced a "positive structural bonus", cross-ownership labor and capital flow produced "positive structural bonus." Implications are decrease intervention in operations, allow free factor movement among sectors, provinces, and ownership; improve capital market and improve labor market to channel skilled workers into the high-tech industry.

INTRODUCTION AND LITERATURE REVIEW

China's current downward pressure on the economy is partly due to the inadequate release of the "structural bonuses." All kinds of bonuses that have promoted the long-term rapid growth in the past are gradually decreasing, including demographic bonuses, resource bonuses and system transition bonuses characterized by the incremental reform. The traditional way that growth occurs that is dependent on the expansion of factor inputs is clearly unsustainable. In the context of the new normal economic environment, optimizing the allocation of factors, namely promoting production factor flows to the industrial, regional and ownership sectors experiencing higher productivity or productivity growth, will create a new bonus space. Thus, inspecting the "structural bonus" generated by factor configuration becomes the basis and prerequisite for finding and releasing a new impetus for economic growth.

Research on "structural bonus" issues has resulted in differing conclusions due to different countries in the studies, differing regions, industries and time periods. Research focused on Germany (Dietrich and Kruger, 2010), India (Cortuk and Singh, 2011), Russia (Voskoboynikov and Gimpelson, 2015), Korea and

Estonia (Juri and Varblane, 2014), and Europe as a whole (Eoin and Don, 2015) has found evidence of a "structural bonus." Studies considering China at a national level conducted by Zhang et al. (2009), Zhang and Wang (2014), Wang and You (2015) and Yin (2016) find a significant existence of a "structural bonus" in factor allocation. Ding and Ning (2011) and Chen (2013) respectively reached the same conclusion in the study of Guangdong and Chongqing provinces. However, some studies have resulted in the opposite conclusion. Li and Lu (2007) argue that the structural changes in China's manufacturing industry has not produced a significant structural bonus, a conclusion similar to that found by Aldrighi and Colistete (2013) in the Brazilian manufacturing industry. Li and Chen (2007), Yao (2009), Zeng and Li (2011), Su et al. (2012) and Wu (2013) all believe that the structural contribution of China's industrial factor re-allocation is low, and that the industrial productivity growth is primarily generated by the within-growth effect. Zhang et al. (2014) found that China's energy productivity growth also primarily results from the within-growth effect. Further, Timmer and Vries (2009) examined the "structural bonus" of 10 economic sectors in 19 countries in Asia and Latin America, believing that their economic growth is primarily due to the increase in productivity among sectors, rather than the reallocation of production factors. Changes in industrial structure can have significant bonus effects on China's economic growth, but the source of the bonus will gradually shift to technological progress (Liu and Zhang, 2008). With the increase of the share of the tertiary industry, the "structural bonus" will gradually translate into "cost disease" (Li et al., 2016). Finally, determining whether the "structural bonus" can be generated will have different results due to different factors of production (Gan and Zheng, 2009; Xin et al., 2015), different corporate characteristics (Hu et al., 2013) and differences across the regions (Zhu et al., 2011).

China's high-tech industry has become a new economic growth measure, and it is a strategic initiative on both national level and local level to vigorously develop the high-tech industry. Among the studies focused on the externality of high-tech industrial structure, Paci and Usai (1999) considered the knowledge spillover effect in the Italian high-tech industrial structure, and found that the diversification of high-tech industrial structure was conducive to promoting technological innovation. Zhao and Wei (2008) used an entropy index and industry concentration index to measure the degree of agglomeration of China's high-tech industry and its relationship to economic growth. Results indicated that China's high-tech industry clusters can bring high economic growth but this growth can also exacerbate the gaps among regions. Sun, Liu and Xu (2011) used the Moran I index method to measure the spillover effect of the high-tech industry structure. The results show that in all high-tech sub-industries except aircraft manufacturing there is a spillover effect that is significant. Tao and Zhou (2015) tested the spatial effect of coupling the information industry and manufacturing on the optimization and upgrading of industrial structure. They concluded that regional industrial coupling showed spatial correlation with industrial structure upgrades and there was a consistency with regional economic development. On the whole, although the existing research had made assessments on the "structural bonus" of high-tech industry, they focus more on knowledge spillover, economic growth or industrial structure upgrades, rarely on factor productivity growth. Moreover, studies of the flow of production factors from high-tech industries tend to focus on cross-industry and cross-regional flows, and less attention is paid to the "structural bonus" generated by cross-ownership flows. This paper will focus on cross-sector, cross-provincial and cross-ownership flows of production factors in the high-tech industry. The factor productivity growth will be deconstructed from multiple dimensions to help determine the structural contribution of factor flows.

Theoretical Foundation of "Structural Bonus"

After World War II, Development Economics which is focused on the growth of developing countries started to rise. Structuralism is one of the theoretical branches of Development Economics and this area of study also began to increase. Structuralism is the opposite of neoclassicism, and these alternative views have historically dominated the field of Development Economics. Structuralists argue that the economies of developing countries are characterized by rigidity, economic lags, periods of shortages, periods of excess, low supply elasticity and similar responses. Therefore, the assumption of economic man acting in a completely rational manner to maximize his utility, is not true and the price mechanism emphasized by neoclassicism will fail in developing countries (Cai, 1995). Structuralists instead use structural analysis and institutional analysis tools to describe the structural imbalances and changes in developing countries, revealing the structural rigidity and institutional rigidity behind the various non-equilibrium phenomena (Ma, 2002). In structuralism, the economic structure is regarded as the “deep factor” in national economic development. After the industrial revolution, many developed countries experienced rapid economic growth, and some developing countries in Asia, Latin America and Africa have experienced Kuznets facts (Chenery, 1960; Lucas, 2004; McMillan and Rodrik, 2011). That is, production factors transfer continuously from the agricultural sectors to the industrial and service sectors, resulting in the transformation and upgrade of the structure, creating a "structural bonus".

The question remains however, how does a “structural bonus” drive economic growth. In essence, economic growth comes from both the expansion of production factors and the increase in factor productivity (Vittorio and Donatella, 2009). When it is difficult for the expansion of production factors to maintain rapid economic growth, improving the productivity of factors has become an important way to promote economic growth. Technological progress is a direct way to increase factor productivity, but technological progress is concerned only with the increase of the *inter*-sectoral factor productivity, ignoring the differences of *intra*-sectoral factor productivity. So, the flow of these factors among sectors at different productivity levels will change the overall factor productivity under the premise that the total amount of factors will remain unchanged. When sectors are in a non-uniform state of factor productivity, and under market economy conditions, production factors will flow from the lower marginal return sectors to the higher ones based on the principle of profit maximization. If the marginal productivity of the factor determines the marginal return, the production factors will be allocated to the sectors with higher marginal productivity under the market mechanism, so that the “structural bonus” is generated and the economic output is increased.

Of course, the above analysis of the mechanism of “structural bonus” is based on the assumption of a market mechanism. Production factors can flow freely under the market price mechanism, spontaneously moving from less efficient sectors to the higher efficient sectors. So that enterprises can enter and exit the market spontaneously and gradually change the economic structure. But at the same time, the negative externalities brought about by market failure, such as incomplete competition, information asymmetry and waste of resources provide a certain theoretical support for the government to become involved in the factor allocation. Lin (2010) proposed “New Structural Economics” which is opposite of what he called “Old Structural Economics.” The New Structural Economics emphasizes the synergies between the market and the government during the process of economic structural change. New Structural Economics argue that the process of generating a “structural bonus” not only requires the market as the basic allocation mechanism, but also needs the government to play a facilitating role to reduce the cost of trial and error when upgrading the structure.

In addition, the “structural bonus” has some specific characteristics. First, the unbalanced development of the economic sectors is a prerequisite for “structural bonus” (Peneder, 2002). The differences in factor productivity and productivity growth rates in various sectors provide the possibility of cross-sectoral flows of production factors. Therefore, the imbalance in economic efficiency of various sectors should not be regarded as a negative outcome as it is the basis of economic structural upgrading under the condition of market mechanism. Second, the “structural bonus” releases gradually, so that it may be inadequate in the short-term and will sacrifice a certain amount of growth (Wei & Wang, 2016). At present, China's economy has entered a period of medium-speed growth from the past long-term rapid growth stage, partly because of the old population bonus and the system bonus loss while the new structural bonus is not fully released. However, the reduction in “growth” is temporary. The elimination or transformation of overcapacity industries, the allocation of production factors to high value-added industries such as high-tech industries will promote the improvement of “economic quality”.

MODEL DESIGN AND DATA DESCRIPTION

In general, the total growth of factor productivity comes from the growth effect of the factor productivity of each sub-sector, and the structural effects of the factors flowing among sub-sectors. The shift-share method can effectively separate the structural effects of productivity growth (Li et al., 2016; Xuemei, 2014; Viktorija, 2015). Therefore, we use the shift-share method to examine the "structural bonus" generated by cross-sector, cross-provincial and cross-ownership flows in China's high-tech industry production sectors, and the model is designed as described below.

We use g to represent the productivity growth rate of factor a, representing labor force and capital. G represents the productivity level of the factors, Y is the industrial output value and S is the factor share. The time period is represented as t (the initial value is 0, the end value is t) and i indicated the different sectors[1]. The model can therefore be represented as:

$$g_t = \frac{G_t - G_0}{G_0} = \frac{\frac{Y_t}{a_t} - \frac{Y_0}{a_0}}{G_0} = \frac{\sum_{i=1}^{n}\left(\frac{Y_{it}}{a_t} - \frac{Y_{i0}}{a_0}\right)}{G_0} \quad (1)$$

and

$$\frac{Y_{it}}{a_t} - \frac{Y_{i0}}{a_0} = \frac{Y_{it}}{a_{it}} * \frac{a_{it}}{a_t} - \frac{Y_{i0}}{a_{i0}} * \frac{a_{i0}}{a_0} = G_{it}S_{it} - G_{i0}S_{i0} \quad (2)$$

Further we have:

$$\begin{aligned} & G_{it}S_{it} - G_{i0}S_{i0} \\ &= G_{i0}S_{it} - G_{i0}S_{i0} + G_{it}S_{it} - G_{i0}S_{it} - G_{it}S_{i0} + G_{i0}S_{i0} + G_{it}S_{i0} - G_{i0}S_{i0} \\ &= G_{i0}(S_{it} - S_{i0}) + (G_{it} - G_{i0})(S_{it} - S_{i0}) + (G_{it} - G_{i0})S_{i0} \end{aligned} \quad (3)$$

Substituting into (1) we have:

$$g_t = \frac{\sum_{i=1}^{n} G_{i0}(S_{it} - S_{i0})}{G_0} + \frac{\sum_{i=1}^{n}(G_{it} - G_{i0})(S_{it} - S_{i0})}{G_0} + \frac{\sum_{i=1}^{n}(G_{it} - G_{i0})S_{i0}}{G_0} \quad (4)$$

From (4) we know that the total growth of factor productivity is decomposed into three parts. The first term on the right is the static shift effect (SSE), which is used to measure the growth effect generated by the flow of factors from lower productivity sectors to higher ones, under the condition that the factor productivity level remains constant. This kind of growth effect is simply caused by structural changes in the factors. If the sector with higher factor productivity absorbs more factors and increases the factor share, the term is positive and called "structural bonus" and otherwise it is negative and called "structural negative bonus". The second term is the dynamic shift effect (DSE), which expresses the growth effect brought by the flow of factors to the sectors with higher productivity growth rate. It reflects the combined effect of the structural change of the factor and the change in productivity. When sectors with increasing factor productivity have net inflow of factors or sectors with decreasing factor productivity have net outflow of factors, the term is positive and called "structural bonus" and otherwise it is negative and called "structural negative bonus". The third term is within-growth effect, which reflects the contribution of each sub-sector's growth of factor productivity under the condition that there are not structural changes of factors.

The *China Statistics Yearbook on High Technology Industry*, sub-divides high-tech industries into five sub-sectors: "manufacture of medicines", "manufacture of aircraft and space craft and related equipment", "manufacture of electronic equipment and communication equipment", "manufacture of computers and office equipment" and "manufacture of medical equipment and measuring instrument"[2]. At this point it is necessary to explanation the data collection and processing procedures. This paper uses the indicator "annual average number of employed personnel" to characterize the labor force factor, and uses the indicator "investment in fixed assets" to characterize the capital factor. The base period is 1995, we use the consumer price indices and the price index for investment in fixed assets to remove the price factor for industrial output and fixed asset investment respectively. In addition to the price index data obtained from *China Statistical Yearbook*, the other data are all collected from *China Statistics Yearbook on High Technology Industry.* Since *China Statistics Yearbook on High Technology Industry* no longer publishes the industrial output value data from 2012 onwards, this paper uses GM (1, 1) Gray Forecast Model to predict the output value of China's high-tech industry from 2012 to 2014.

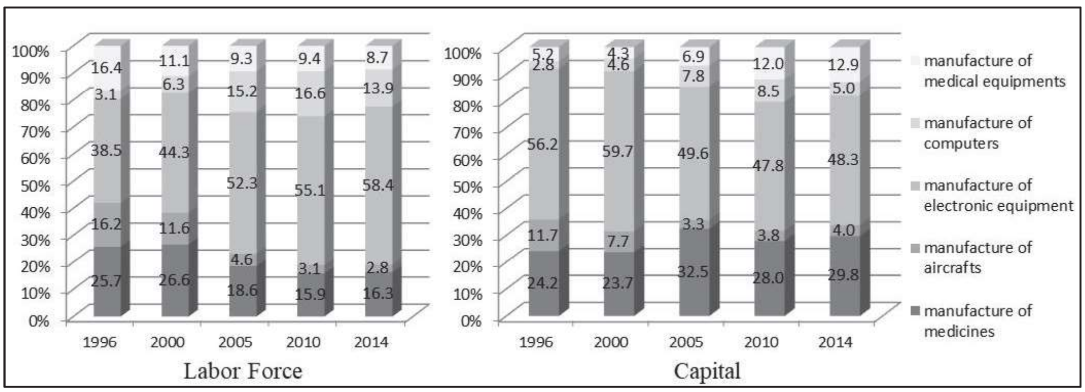
The Evolution of Factor Structure and Productivity

As mentioned above, it is a prerequisite for testing the "structural bonus hypothesis" that the sectoral share of production factors be changed due to the factor flows and the factor productivity as the productivity growth rates of sectors are different in the study interval (Peneder, 2002). The profitable factors may flow among different sectors. If the factors are constantly being allocated from sectors with lower-productivity or lower-growth rate to higher ones, and the output is increased because of the optimal allocation of factors and the upgrade of the industrial structure, then the “structural bonus” will be generated, otherwise the ”structural bonus” will not occur and a “structural negative bonus” may occur instead.

Cross-Sector Analysis

The distribution of labor force and capital factors in the sub-sectors of high-tech industry in some years is shown in Figure 1, from which we can see the factor structure has changed in stages. Considering the Labor force, manufacture of electronic equipment always accounted for the largest proportion, followed by the manufacture of medicines, and the other three manufacturing sectors accounted for relatively small proportions.

FIGURE 1
THE CROSS-SECTOR EVOLUTION OF FACTOR STRUCTURE



Data Source: Calculated by the authors

The proportion of the labor force in manufacture of electronic equipment increased year by year, from 38.5% in 1996 to 58.4% in 2014. The manufacture of computers increased from 3.1% in 1996 to 16.6% in 2010, and decreased to 13.9% in 2014. Manufactures of medicines (declined from 25.7% to 16.3%), aircraft (declined from 16.2% to 2.8%) and medical equipment (declined from 16.4% to 8.7%) accounted for an overall downward trend of the proportion. Considering the capital factor, we observe that manufacture of electronic equipment and medicines account for the largest and second largest proportion over the years, and the proportion of the other three industries are less. However, the changes in the capital factor structure are smaller than those of the labor force structure. Shares of manufactures of medicines and electronic equipment remained relatively stable, at about 30% and 50% respectively. The manufacture of aircraft dropped from 11.7% in 1996 to 3.3% in 2005, and then remained at about 4%. The manufacture of computers rose from 2.8% in 1996 to 7.8% in 2005, and then fluctuated in a small range. The manufacture of medical equipment showed an upward trend as a whole, rose from 5.2% in 1996 to 12.9% in 2014.

Table 1 shows the productivity and productivity growth rates of the two production factors in each sub-sector. It can be seen that there is significant difference in the productivity and growth rates of each sector over the years. First, labor force. Due to technological progress and the improvement of the quality of workers, five sub-sectors are showing increasing trend in productivity year by year. Such as the manufacture of medicines, its productivity increased from 104.9 thousand yuan / person in 1996 to 1081.2 thousand yuan / person in 2014. Horizontal comparison shows that the labor productivity of manufacture of computers is much higher than other industries in each year. Manufacture of aircrafts is located in the end. Especially in 1996, the labor productivity of manufacture of computers (433.5 thousand yuan / person) was about 10.5 times higher than that of manufacture of aircrafts (41.4 thousand yuan / person).

TABLE 1
THE CROSS-SECTOR EVOLUTION OF FACTOR PRODUCTIVITY AND PRODUCTIVITY GROWTH RATE

	Year	Labor Force				
		Medicines	Aircrafts	Electronic	Computers	Medical
Productivity	1996	104.9	41.4	152.7	433.5	55.2
	2000	198.8	99	401.1	792.2	156.6
	2005	396.1	301	559.7	1212.4	333.2
	2010	768.6	538.2	677.1	1238.1	621.9
	2014	1081.2	830.2	1218.4	3445.5	1177.2
Growth Rate	1996-2000	89.48	138.98	162.77	82.72	184.01
	2000-2005	99.27	203.95	39.52	53.05	112.75
	2005-2010	94.06	78.81	20.98	2.12	86.61
	2010-2014	40.67	54.26	79.94	178.28	89.29
	1996-2014	930.70	1903.62	698.14	694.73	2034.43
	Year	Capital				
		Medicines	Aircrafts	Electronic	Computers	Medical
Productivity	1996	16.51	8.47	15.44	73.06	25.72
	2000	14.84	9.98	19.82	71.34	27.16
	2005	6.74	12.57	17.51	69.97	13.41
	2010	6.71	6.75	12.00	37.26	7.50
	2014	4.27	4.10	10.60	68.70	5.71
Growth Rate	1996-2000	-0.10	0.18	0.28	-0.02	0.06
	2000-2005	-0.55	0.26	-0.12	-0.02	-0.51
	2005-2010	0.00	-0.46	-0.31	-0.47	-0.44
	2010-2014	-0.36	-0.39	-0.12	0.84	-0.24
	1996-2014	-0.74	-0.52	-0.31	-0.06	-0.78

Note: Labor force productivity represents per capita output, calculated as the output value divided by the number of labor force, and the unit is "thousand yuan / person". Capital productivity represents the output value created by one yuan, calculated as the output value divided by the number of capital, and the unit is "yuan". The productivity growth rate of factors is calculated using "$g_t = (G_t - G_0)/G_0$", and the unit is "%".
Data Source: Calculated by the author

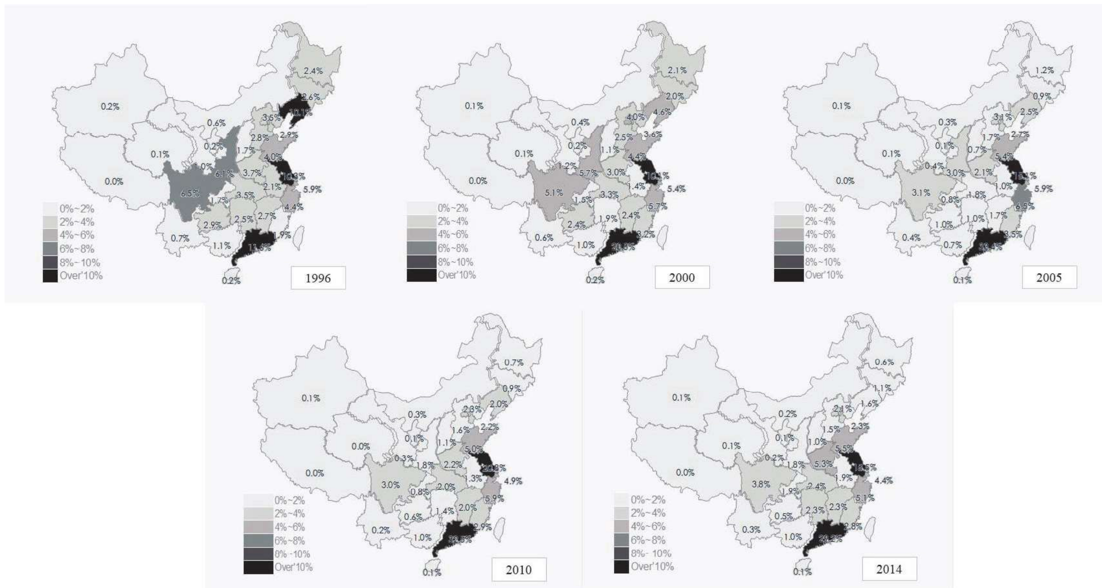
In terms of growth rates, there are significant differences in all sub-industries in each time period, and they are diverse with the evolution of time. Such as 2000-2005, the growth rate of manufacture of aircrafts is as high as 203.95%, while the manufacture of electronic equipment is as low as 39.52%. Overall, the growth rate of manufacture of medical equipment in each stage is relatively high and that of manufacture of computers is relatively low. For the whole stage 1996-2014, manufacture of medical equipment labor growth rate is 2034.43%, while manufacture of computers is 694.73%. Second, considering the capital factor from the productivity perspective, five industries as a whole showed a declining trend. As in the case of labor factor, the capital productivity of the manufacture of computers is much higher than that of other industries, and manufacture of aircrafts is relatively low. The capital productivity of the manufacture of computers in 2014 (68.70 yuan) is about 16.7 times higher than that of the manufacture of aircraft (4.10 yuan). In terms of growth rates, the capital productivity of high-tech industries has shown a negative growth in most cases, with growth rates generally below -0.1%, except for some certain cases. For the whole stage of 1996-2014, the growth rate of the manufacture of computers is -0.06% which is the lowest, and the highest one is manufacture of medical equipment whose growth rate is -0.78%.

In summary, industries with higher labor productivity (such as the manufacture of computers and the manufacture of electronic equipment) clearly absorbed labor force from industries with lower productivity (such as manufacture of aircrafts and manufacture of medical equipment). However, the labor force is not clearly moving towards industries with higher growth rates, that is to say, industries with higher productivity are lower in growth rate (like manufacture of computers). It can be inferred that the cross-sector mobility of labor force can lead to certain "structural bonus," in which the static shift effect contributes more. The capital factor flows mainly from manufacture of aircrafts with lower productivity to manufacture of computers with higher productivity, which will produce a certain static shift effect.

Cross-Province Analysis

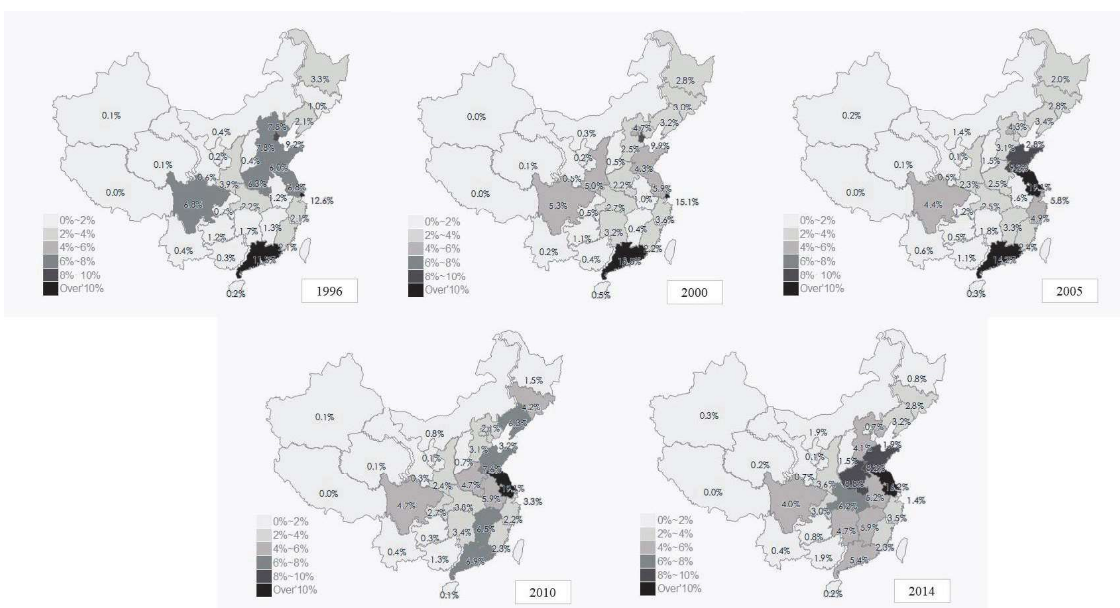
Figure 2 and Figure 3 show the changes of provincial distribution of labor force and capital. Overall, the production factors are mostly distributed in Jiangsu, Guangdong and other southeast coastal provinces over the years, followed by Liaoning, Henan and other northeast and central provinces. Western provinces generally account for smaller shares except Sichuan and Shaanxi. In 1996-2014, the labor force flows mainly from the northeast and western provinces to the southeast coastal provinces, and central provinces remain relatively stable. For example, the proportion of labor in Liaoning Province dropped from 10.1% in 1996 to 1.6% in 2014, Shaanxi Province dropped from 6.1% in 1996 to 1.8% in 2014, while Jiangsu Province rose from 10.3% to 18.5%. In addition, the flow of labor force in some central provinces was characterized by U-shaped, such as Henan Province, the share of labor force fell from 3.7% in 1996 to 2.1% in 2005, and then rose to 5.3% in 2014. In terms of the structural changes of capital factor, we see a flow from the economically developed provinces to the central provinces. Beijing, Shanghai and Guangdong have obvious capital outflows, like Shanghai's capital share in 1996 is 12.6% and 1.4% in 2014. Central provinces such as Anhui, Jiangxi and Hubei have capital inflows, like Jiangxi's capital share increases from 1.3% to 5.9% during 1996 to 2014. In addition, capital flows of some provinces are characterized as positive U-shape (such as Henan) and inverted U-shape (such as Liaoning).

FIGURE 2
THE CROSS-PROVINCIAL EVOLUTION OF LABOR FORCE STRUCTURE



Data Source: Calculated by the authors

FIGURE 3
CROSS-PROVINCIAL EVOLUTION OF CAPITAL STRUCTURE



Data Source: Calculated by the authors

The results of calculating the variance of provincial factor productivity and growth rate are shown in Table 2. The variance values reflect the discrete degree of factor productivity and growth rate of provinces. The closer to 0 the variance is, the lower the degree of dispersion, the smaller the gap among provincial factor productivity and growth rate. As can be seen from Table 2, in terms of the labor force, the variance values of productivity and growth rate are far from 0, indicating that the provincial difference is large.

TABLE 2
VARIANCE VALUES OF PROVINCIAL FACTORS PRODUCTIVITY AND GROWTH RATES

	Year	Labor Force	Capital
Productivity	1996	6.14	11.14
	2000	15.61	12.52
	2005	27.21	10.12
	2010	27.45	10.11
	2014	44.12	11.36
Growth Rate	1996-2000	87.73	565.20
	2000-2005	50.69	61.83
	2005-2010	41.87	56.13
	2010-2014	36.03	37.23
	1996-2014	917.30	94.41

Data Source: Calculated by the authors

The difference in productivity is increasing and the difference in growth rate is decreasing year by year. With the specific data we find that the central and western provinces such as Shanxi and Gansu have lower labor productivity over the years, while Beijing, Shanghai and other economically developed areas are always in the first place. The labor productivity growth rate ranking shows that the economically developed provinces are relatively backward, and the central and western provinces rank better, from which we can see although the labor productivity of central and western provinces is low, it has greater rooms for growth. In terms of the capital factor, the productivity variance fluctuates within a small range between 10 and 13, indicating that the provincial capital productivity is significantly different but the difference is relatively stable. As with the labor force factor, economically developed provinces are generally higher in capital productivity than those of the economically underdeveloped provinces. For the growth rate of capital productivity, the whole country generally shows a negative growth in many stages. And the data of Table 2 shows that although the difference of the provincial capital productivity growth rate is large, it shows a trend of gradually narrowing.

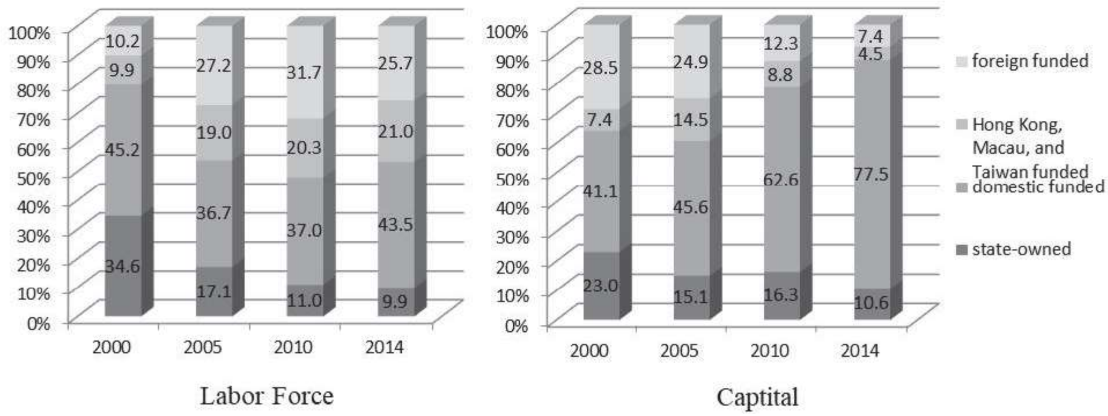
In summary, during 1996 to 2014, the labor force flow mainly from central and western provinces with lower labor productivity to southeast coastal provinces with higher productivity. But because central and western provinces are generally higher in productivity growth rate, we speculate that the SSE of labor force should be positive and the DSE should be negative. The capital mainly flow from economically developed provinces with higher capital productivity (Such as Beijing, Shanghai and Guangdong) to central provinces with lower productivity (such as Anhui, Jiangxi and Hubei), which reduced capital productivity growth.

Cross-Ownership Analysis

The distribution of production factors in certain years[3] with differing ownership-type is provided in Figure 4, from these results we can see the obvious flow of factors. In terms of labor force, the share of state-owned enterprises drops significantly, from 34.6% in 2000 to 9.9% in 2014. The labor force flows primarily toward foreign funded enterprises and Hong Kong, Macao and Taiwan (HMT) funded enterprises.

FIGURE 4

CROSS-OWNERSHIP EVOLUTION OF FACTOR STRUCTURE



Data Source: Calculated by the authors

The share of foreign funded enterprises increased from 10.2% to 31.7%, and then reduced to 25.7% and that of HMT funded enterprises increased from 9.9% to 21.0%. The labor flow of domestic funded enterprises is in a weak positive U-shape trend. In terms of the capital factor, the share of state-owned enterprises (from 23.0% to 10.6%) and the share of foreign funded enterprises (from 28.5% to 7.4%) were declining, but in different degrees. HMT funded enterprises absorbed their shares in the 2000-2005 period (from 7.4% to 14.5%), but continued to decline in the period from 2005 to 2014 (from 14.5% to 4.5%). The capital factor mainly flows towards domestic funded enterprises, and its share increases continuously from 41.1% in 2000 to 77.5% in 2014. Domestic funded enterprises gather the majority of the capital of high-tech industry.

TABLE 3
CROSS-OWNERSHIP EVOLUTION OF FACTOR PRODUCTIVITY AND PRODUCTIVITY GROWTH RATE

	Year	Labor Force			
		State-owned	Domestic Funded	HMT Funded	Foreign Funded
Productivity	2000	241.4	184	377.2	803.8
	2005	472.9	359.6	509.2	975.5
	2010	661.9	651.1	658.3	995.1
	2014	995.9	1135.1	999.7	1607.7
Growth Rate	2000-2005	95.88	95.45	34.98	21.36
	2005-2010	39.97	81.05	29.30	2.01
	2010-2014	50.47	74.33	51.85	61.56
	2000-2014	312.56	516.89	165.02	100.01
	Year	Capital			
		State-owned	Domestic Funded	HMT Funded	Foreign Funded
Productivity	2000	28.45	15.87	39.80	22.50
	2005	16.32	8.81	20.30	32.42
	2010	6.43	5.56	21.97	37.18
	2014	6.65	4.55	33.69	39.60
Growth Rate	2000-2005	-42.65	-44.47	-49.00	44.05
	2005-2010	-60.59	-36.87	8.26	14.71
	2010-2014	3.42	-18.27	53.33	6.51
	2000-2014	-76.63	-71.35	-15.34	75.99

Note: The unit of labor force productivity is “thousand yuan / person”, the unit of capital productivity is “yuan”, and the unit of productivity growth rate is “%”.
Data Source: Calculated by the author.

Table 3 shows the evolution of factor productivity and growth rates of different ownership enterprises. Considering the labor factor first, we see that in terms of productivity, foreign funded enterprises have ranked first in four categories of ownership enterprises over the years, and have obvious advantages. Domestic funded enterprises had the lowest labor productivity in 2000 (184 thousand yuan/ person) and 2005 (359.6 thousand yuan / person), and then climbed to 1135.1 thousand yuan / person, second only to foreign-funded enterprises with 1607.7 thousand yuan / person. In year 2000, state-owned enterprises showed a certain weakness to HMT funded enterprises (state-owned enterprises 241.4 thousand yuan / person, HMT funded enterprises 377.2 thousand yuan / person), in other years, labor productivity of the two ownership enterprises is relatively close. Considering the growth rate we see that the domestic funded enterprises show advantages at various stages, and the growth rate of foreign-funded enterprises is relatively low. For the period of 2000-2014, the growth rate of labor force in domestic funded enterprises is 516.89%, and that of foreign funded enterprises is 100.01%. Examining the capital factor vertically, the capital productivity of state-owned enterprises and domestic funded enterprises is decreasing year by year, and that of foreign funded enterprises is increasing year by year, while that of HMT enterprises shows positive U shape. We can see from the horizontal comparison that, except the year of 2000 in which HMT funded enterprises’ capital productivity (39.80 yuan) was the highest, in other years, foreign and domestic funded enterprises had the highest and lowest capital productivity respectively. In terms of growth rate, the capital productivity has shown negative growth in many years, and the gap among the four ownership-types is significant as in previous years. For the whole stage of 2000-2014 years, the capital growth rate of state-owned enterprises is the lowest, -76.63%. However, we can see that foreign funded enterprises have shown positive growth in capital productivity at all stages, and the growth rate of capital productivity of foreign funded enterprises has reached 75.99% during 2000-2014.

In summary, it is apparent that the labor force primarily flows from state-owned enterprises with lower labor productivity to foreign funded enterprises with higher productivity, but foreign funded enterprises' productivity growth rate is relatively low. We initially suggest that labors' mobility can bring a certain "structural bonus", but due to the negative effect of the dynamic shift effect, the "structural bonus" will not be very large. In terms of capital factor, in four ownership-types of enterprises, foreign funded enterprises show higher capital productivity and growth rate, but the capital mainly flows to domestic funded enterprises, hence the cross-ownership movement of capital may have negative structural effect.

The above data shows that the production factors of high-tech industry have significant cross-sector, cross-provincial and cross-ownership flows in the research range, and the productivity and growth rate of factors in each time period has obvious differences in sector structure, provincial structure and ownership structure, which meets the requirements of testing "structural bonus hypothesis". To determine if the "structural bonus" can be generated we examine the preliminary judgment of factor flows and the fuzzy prediction of "structural bonus" and need to further decompose the growth effect of factor productivity.

THE EXAMINATION OF "STRUCTURAL BONUS HYPOTHESIS"

Using the derivation of formula (4), we decompose the productivity growth of the production factors in high-tech industry, and test the "structural bonus" generated by cross-sector, cross-provincial and cross-ownership flows of production factors.

Cross-Sector Examination

TABLE 4(A)
PRODUCTIVITY GROWTH EFFECT DECOMPOSITION OF FACTORS' CROSS-SECTOR FLOW

Factors	Year	Total Growth Rate（%）	Effect Decomposition（%）		
			Structural Effect	SSE	DSE
Labor Force	1996-2000	168.86	19.22	9.63	9.60
	2000-2005	92.49	32.80	26.88	5.91
	2005-2010	30.13	4.02	9.56	-5.54
	2010-2014	92.35	-8.30	-1.95	-6.35
	1996-2014	1195.36	22.38	18.22	4.16
Capital	1996-2000	21.12	36.89	35.40	1.48
	2000-2005	-14.12	-29.11	-63.13	34.02
	2005-2010	-32.55	-2.55	-10.31	7.76
	2010-2014	-9.92	185.07	86.63	98.43
	1996-2014	-36.79	-17.41	-43.05	25.63

TABLE 4(B)
PRODUCTIVITY GROWTH EFFECT DECOMPOSITION OF FACTORS' CROSS-SECTOR FLOW

Factors	Year	Effect Decomposition（%）					
		WGE	Medicines	Aircrafts	Electronic	Computers	Medical
Labor Force	1996-2000	80.78	12.43	4.80	49.17	5.80	8.58
	2000-2005	67.20	18.37	8.21	24.55	9.24	6.84
	2005-2010	95.98	38.61	6.07	34.19	2.18	14.93
	2010-2014	108.30	6.92	1.26	41.63	51.22	7.27
	1996-2014	77.62	18.26	9.29	29.79	6.88	13.40
Capital	1996-2000	63.11	-11.18	4.95	68.58	-1.31	2.08
	2000-2005	129.11	66.17	-6.83	47.45	2.20	20.12
	2005-2010	102.55	0.18	3.30	47.46	44.57	7.03
	2010-2014	-85.07	57.60	8.45	56.47	-225.68	18.09
	1996-2014	117.41	47.25	8.17	43.43	1.92	16.64

Note: The values of the SSE, DSE, and WGE columns are results that the first, the second and the third item of the right side of formula (4) divided by the item on the left side respectively.
Data Source: Calculated by the authors

The productivity growth effect of the cross-sector flow of production factors of is decomposed, as shown in table 4. We first consider the labor force. For the entire period of 1996-2014, the contribution of the structural effect to labor productivity growth is 22.38%, and the contribution of the remaining 77.62% comes from WGE of various industries. Although the sectors' own growth is the main factor in the growth of labor productivity, the allocation of the labor force still releases a certain "structural bonus", we observe that the structural effect, SSE (18.22%) is higher than DSE (4.16%). In WGE, the contribution of electronic equipment manufacturing (29.79%) is the largest, and the contribution of computers manufacturing (6.88%) is the smallest. An overall observation of the effect decomposition of each period, shows that in addition to the 2000-2005 time period, the structural effect generally exhibits a decreasing trend, while trend in WGE is increasing. It appears that although the industry structure of the labor force has some positive effects, its allocation efficiency is deteriorating.

We move next to consider the capital factor. As a whole, the industry type of the capital has a positive structural effect, but with little effect[4]. In the 1996-2014 time period, the total growth rate is negative (-36.79%), and the structural effect is also negative (-17.41%), indicating that the cross-sector flow of capital produced a certain "structural bonus" which reduced the negative growth of productivity. However, the WGE is 117.41%, lowering the productivity growth. The structure effect is primarily composed of SSE (-43.05%), indicating that capital flows toward sectors with higher productivity. In WGE, each sub-industry has negative influence to varying degrees. We also note that the structural effect and WGE of capital factor have not shown the regular phase change.

At this point it appears that the cross-sector flow of the factors in the high-tech industry has produced a certain "structural bonus." Although the bonus has much potential to grow, it appears that the industry barriers to the factor flow have been broken to some extent.

Cross-Provincial Examination

The productivity growth effect of production factors' cross-provincial flow is decomposed as shown in Table 5.

TABLE 5
PRODUCTIVITY GROWTH EFFECT DECOMPOSITION OF FACTORS' CROSS-PROVINCIAL FLOW

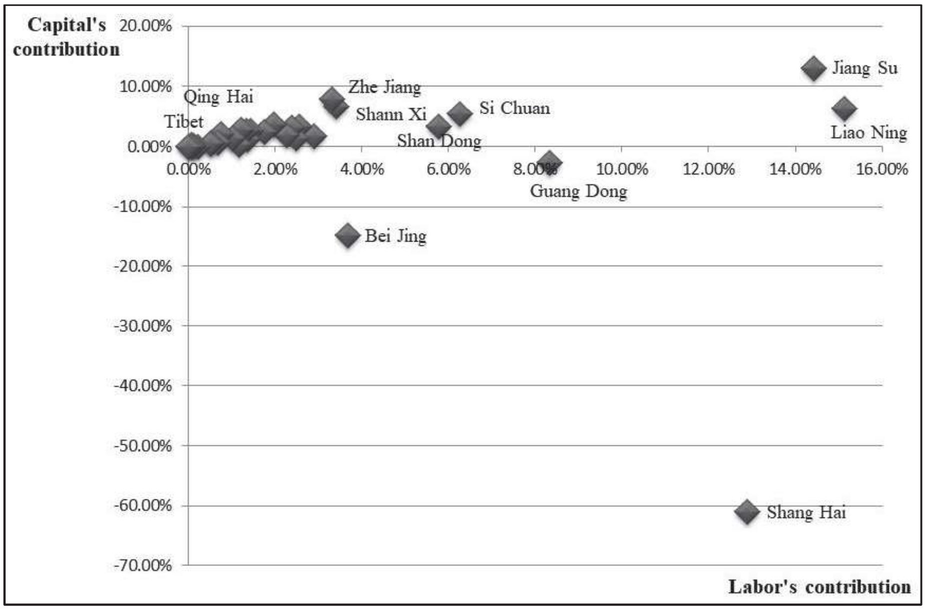
Factors	Year	Total Growth Rate（%）	Effect Decomposition（%）			
			Structural Effect	SSE	DSE	WGE
Labor Force	1996-2000	172.96	11.96	10.06	1.90	88.04
	2000-2005	87.74	13.83	11.78	2.05	86.17
	2005-2010	30.18	-6.67	-2.86	-3.81	106.67
	2010-2014	47.20	-10.94	-2.66	-8.28	110.94
	1996-2014	881.96	-0.27	3.33	-3.60	100.27
Capital	1996-2000	23.58	-6.38	75.19	-81.58	106.38
	2000-2005	-16.11	138.26	-156.70	294.96	-38.26
	2005-2010	-32.57	91.76	65.68	26.08	8.24
	2010-2014	-31.18	61.28	35.36	25.92	38.72
	1996-2014	-51.89	102.31	-32.62	134.94	-2.31

Note: The values of the SSE, DSE, and WGE columns are results that the first, the second and the third item of the right side of formula (4) divided by the item on the left side respectively.
Data Source: Calculated by the authors

On the whole, the structure effect of labor force's interprovincial migration gradually decreases in different stages (it only increased slightly in 2000-2005 phase). The structural contribution reduced from 11.96% in period 1996-2000 to -10.94% in 2010-2014. For the complete time period of 1996-2014, the contribution of the structural effect is -0.27% (including SSE 3.33% and DSE -3.60%), the contribution of WGE is 100.27%, which indicates that the cross-provincial flow of labor produces a "structural negative bonus." The cross-provincial flow of the capital factor during the 1996-2014 time period generates a "structural negative bonus", which promotes the negative growth of capital productivity (-51.89%). For the whole time period, the structure effect is 102.31%, but SSE is -32.62%, indicating that the capital factor was flowing to the provinces with higher productivity. WGE was observed to have a weak positive impact (-2.31%). In addition, the changes in the capital's structure effect and WGE are irregular.

The provincial contribution of WGE across the time period is shown in figure 5 [5]. The WGE of labor force is the entire source of labor productivity growth, and the contribution rate is 100.27%. Developed coastal provinces, such as Liaoning, Jiangsu, Shanghai and Guangdong, contribute relatively more than do the inland provinces. Western underdeveloped provinces, such as Ningxia, Xinjiang, Qinghai and Tibet tend to contribute less.

FIGURE 5
THE PROVINCIAL CONTRIBUTION OF WGE OF FACTORS' CROSS-PROVINCIAL FLOW IN 1996-2014



Data Source: Calculated by the authors

Overall, the WGE of capital has a negative contribution (-2.31%). Provinces with higher contribution are Jiangsu, Zhejiang, Shaanxi, and Liaoning. But interestingly, Shanghai, Beijing and Guangdong contribute the lowest, of with Shanghai ranking last with a contribution rate of -60.89%. Overall, the two provinces of Jiangsu and Liaoning have higher WGE both in labor and capital.

The cross-provincial flow of labor and capital has produced "structural negative bonus", indicating that the provincial barriers have hindered the flow of production factors. The production factors of high-tech industry fail to realize the optimal allocation in these areas because of the household registration system, the land system and the industrial policies. The presence of these systems results in the urban-rural and regional segmentation of labor and capital, restricting the free cross-regional flow of production factors and causing resource misallocation. In addition, the technical talents required in the high-tech industry labor force, may allow the members of this labor force to select where they wish to be employed. This will also impact the free cross-regional flow of the labor force.

Cross-Ownership Examination

The productivity growth effect on production factors' cross-ownership flow is decomposed as shown in table 6. For the labor factor, during the 2000-2014 time period, the contribution rate of the structural effect is 9.98%, and the contribution rate of WGE is 90.02%. The cross-ownership flow of the labor force produces a certain "structural bonus." In the structural effect, the SSE is positive (11.11%) while the DSE is negative (-1.13%), indicating that the labor force tends to flow toward sectors with higher labor productivity. In WGE, the contribution of domestic funded enterprises is far ahead (46.36%), while HMT funded enterprises contribute the least (6.66%). Throughout the evolution of the effect decomposition, the structural effect is gradually reducing at each stage (SSE decreases greatly, while DSE increases slightly), while the WGE is gradually increasing.

TABLE 6(A)
PRODUCTIVITY GROWTH EFFECT DECOMPOSITION OF FACTORS' CROSS-OWNERSHIP FLOW

Factors	Year	Total Growth Rate（%）	Effect Decomposition（%）		
			Structural Effect	SSE	DSE
Labor Force	2000-2005	100.83	34.08	39.08	-4.99
	2005-2010	32.73	8.02	12.24	-4.23
	2010-2014	59.15	-6.23	-4.64	-1.59
	2000-2014	324.21	9.98	11.11	-1.13
Capital	2000-2005	-22.05	12.93	-9.27	22.20
	2005-2010	-36.89	76.08	54.77	21.31
	2010-2014	-21.31	130.91	97.35	33.56
	2000-2014	-61.29	61.81	26.65	35.17

TABLE 6(B)
PRODUCTIVITY GROWTH EFFECT DECOMPOSITION OF FACTORS' CROSS-OWNERSHIP FLOW

Factors	Year	Total Growth Rate（%）	Effect Decomposition（%）				
			WGE	State-owned	Domestic Funded	HMT Funded	Foreign Funded
Labor Force	2000-2005	100.83	65.92	27.79	27.53	4.54	6.06
	2005-2010	32.73	91.98	17.19	56.90	15.05	2.84
	2010-2014	59.15	106.23	8.13	39.68	15.35	43.08
	2000-2014	324.21	90.02	28.17	46.36	6.66	8.83
Capital	2000-2005	-22.05	87.07	56.51	58.65	29.07	-57.15
	2005-2010	-36.89	23.92	23.12	22.96	-3.77	-18.39
	2010-2014	-21.31	-30.91	-1.53	27.07	-43.82	-12.64
	2000-2014	-61.29	38.19	36.53	33.85	3.27	-35.48

Note: The values of the SSE, DSE, and WGE columns are results that the first, the second and the third item of the right side of formula (4) divided by the item on the left side respectively.
Data Source: Calculated by the author.

If we consider the capital factor during the period of 2000-2014, the total growth rate of the capital factor is negative (-61.29%), while the contribution of structural effects is positive (61.81%). This means that the cross-ownership flow of capital produces a "structural negative bonus." In the structural effect, SSE (26.65%) and DSE (35.17%) are all negative and show a decreasing trend in each stage, this indicates that capital is increasingly allocated to the ownership sectors with higher efficiency. The WGE is also negative, and produces a negative impact on the growth of capital productivity. Across all the ownerships, only the WGE of foreign funded enterprises has a positive effect (-35.48%).

The emergence of a "structural bonus" reflects the effectiveness of reform in China's economic ownership structure. From 2000 to 2014, the number of foreign funded enterprises in China's high-tech industries increased from 1441 to 4479 (about 3 times that of state-owned enterprises in the same period), and the number of employees increased from 610 thousand to over 3 million (about 2.6 times that of state-owned enterprises in the same period). The rapid growth of foreign funded enterprises promotes state-owned enterprises with lower productivity to release a large portion of the labor force. The capital ownership structure is somewhat unreasonable, which is in part due to capital market distortions caused by improper administrative intervention. The bias caused by national public policies allows enterprises with different ownership to experience different capital acquisition costs (Midrigan & Xu,2014). China's financial market is dominated by the four major state-owned banks, with a smaller market size available for small and medium sized commercial banks. The market share of bonds, funds and stocks are limited to the financial system. The main source of financing for enterprises is state-owned banks, these banks may show some preferences based on the industrial policies, thus interfering with the free flow of capital into sectors with higher productivity or higher growth rate, resulting in "negative profit structure."

CONCLUSIONS AND IMPLICATIONS

The goal of this paper is to examine whether the flow of factors in China's high-tech industry has generated "structural bonus" during the recent past. Decomposing the growth effects of the factors' productivity using the shift-share method, we examined the extent that factors' cross-sector, cross-provincial and cross-ownership configuration produce structural effects. Our analyses and tests, lead us to draw the following conclusions:

First, the cross-sector flow of labor and capital has produced a certain "structural bonus", but it still indicates that there is much potential for growth. During 1996-2014, the industry allocation of the labor force has provided a positive structural contribution to productivity growth. The capital factor has also had a positive structural effect during this period, which has hindered the negative growth of productivity. However, the "structural bonus" from the production factors' cross-sector flow is still small.

Second, the cross-provincial flow of labor and capital has produced a "structural negative bonus." Provinces with higher labor productivity tend to have lower growth rate, thus the flow to provinces with higher labor productivity produces positive SSE and negative DSE, resulting in negative structural effect during the 18 year period of 1996-2014. As with the labor force, the capital factor also has negative influence on the growth of capital productivity during this same period.

Third, the cross-ownership flow of labor has produced a weak "structural bonus", and the cross-ownership flow of capital has created a "structural negative bonus." During the period of 2000-2014, the cross-ownership flow of the labor force has had a positive structural effect, but the effect is slight. At the same time, the cross-ownership flow of capital promotes the negative growth of capital productivity and creates a negative bonus.

The above analyses and test results show that ensuring the full and free flow of production factors is a necessary condition for high-tech industries to generate a "structural bonus." Irrational administrative intervention will hinder the production factor allocation to sectors with higher resource efficiency (Hsieh and Klenow, 2009; Luo et al., 2012), and hinder the emergence of a "structural bonus." This research has shown that the cross-sector flow of both labor and capital produced "structural bonus", which to some extent reflects the free cross-sector flow of production factors of the high-tech industry. However, the cross-provincial flow of labor and capital and the cross-ownership flow of capital created a "structural negative bonus", which suggests that administrative intervention should be reduced in order to promote the flow of the high-tech industry's production factors. To accomplish this, the regional and ownership discrimination in the financing of high-tech industries should be discontinued. Selective industrial policies often cause market failure as a result of market information asymmetry, therefore improving the financing system environment, breaking institutional barriers to the free flow of the capital factor is conducive to optimizing the allocation of capital in different provinces and ownership enterprises. In addition, based on the regulation and transformation of government functions in developing a decisive role for the market in capital allocation, we should also continue to broaden the financing channels available to the high-tech industry, and construct pluralistic and fair financing environment. Secondly, gradually establish a unified labor market for the high-tech industry. There are still some provincial border barriers to the high-tech industry labor market. In addition to the factors of the natural and human environment, a primary barrier is the household registration, social security system and other institutional barriers which produce a "structural negative bonus" and cause the loss of economic efficiency. It is understood that China does not currently have the conditions to abolish the household registration system, but gradually expanding the reform of the household registration system and eliminating the labor market segmentation of high-tech industry should be the direction of these efforts.

ENDNOTES

1. The "sectors" here should be broadly understood. When we examine the cross-sector flow of factors, i is five sub-sectors of the high-tech industry and n=5. When we examine the cross-provincial flow of factors, i is 31 provinces and autonomous regions and n=31. When we examine the cross-ownership flow of factors, i represents the four forms of ownership of high-tech enterprises and n=4.
2. To facilitate the presentation, the five sub-sectors will be renamed for short as "manufacture of medicines", "manufacture of aircrafts", "manufacture of electronic equipment", "manufacture of computers" and "manufacture of medical equipment" respectively.
3. Cross-ownership data can be collected as the earliest as the year of 2000.
4. Because the total growth rate is negative, the negative value of structure effect indicates that the structural effect has a negative effect on the negative growth of productivity, that is, the structure effect is positive, and the following is the same.
5. Some provinces' names are not marked.

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