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The Driving Effects and Conduction Paths of Chinese High-Tech Industry on National Economy

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Abstract

Based on the social accounting matrix (SAM) and multiplier decomposition method, this paper studies the driving effects of high-tech industry on various sectors of Chinese national economy. The results demonstrate that high technologies can produce the most direct and substantial impacts on secondary industry with growingly intensified influnces, yet the driving effects of high-tech industry on tertiary industry have not been fully displayed. More job opportunities are created as a result of growth of high-tech industry. However, there has been a tendency that capital takes place of labor with the development of high technology. Results of structured paths also suggest that high-tech industry can have remarkable and powerful effects on the output growth of secondary industry, but there may be a long time lag. To the contrary, effects resulting from high-tech industry are relatively weak on tertiary industry, while conduction of such effects is swift. On balance, driving effects of high-tech industry on the growth of employment in various industries are slightly lessened. Moreover, we can get the conclusion that high technology's impacts on the capital accumulation in secondary and tertiary industries become increasingly intensified.

JEL Codes:: E16, E27

Key Words: High-tech industry; Driving effect; Conduction path; Social accounting matrix

1. Introduction and Literature Review

High-tech industries have secured an important position in the development of Chinese national economy and have made increasingly powerful contributions to the economic growth. In the year from 2001 to 2008, there had been an average annual rate of 24.18% in the growth

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of high-tech added values. Meanwhile, proportion occupied by high-tech product in the exports of commodities had grown from 17.5% to 29.05%. Effects of high-tech industries on driving other industries are gradually emerging. In the period from 2005 to 2008, the percentage of knowledge intensive service industries in China' GDP had increased from 8.93% to 10.38%.

It is well known that high-tech industries have significantly leading and driving effects on the long-term growth of national economy. Development of high-tech industries serves as the main force to drive technical progress and facilitates the adjustment of industrial structure, so it can function as a key impetus to upgrading of manufacturing and service industries. The progress of high-tech industries is also helpful to the optimization of element configuration and in turn, to the reasonable adjustment of income distribution. So how to correctly perceive the degree of high-tech industries' driving effects on various sectors of national economy is of great practical significance. Furthermore, the analysis of such effects' conduction paths is conductive for formulating industrial development policies and maintaining the sustainable development of economy.

Many scholars focus on the driving effects of high-tech industries on national economy, such as direct contributions arising from high-tech industries to national economy. In an empirical study, Chongvilaiva (2008) holds that capital deepening for high-tech industries produces significant influences on the growth of total factor productivity. By employing the grey relational analysis method, Zhao and Wei (2006) analyze the contribution of high-tech industries to GDP and industrial added values. Driving effects of high-tech industries on traditional industries are also hot topics, such as the spillover effects of R&D investment on secondary and tertiary industries (Kuen-Hung and Jiann-Chyuan, 2004) or the sector connections between high-tech and low-tech industries (Hauknes and Knell, 2009). From another perspective, Jin (2003) argues that the fuse between high technologies and various industries enables high-tech industry to serve as the key force to promote the growth of traditional industries.

There are also some researches about the optimization of factor allocation and other influences caused by high-tech industry. Berndt et al. (1992) propose that increased investment in high technologies can add the demand for non-production workers[2] and allow production workers to enhance their production skills through education and training. Alexander and Rekha (2007) regard that for different types of companies, high-tech innovations may create different "employment effects", but on balance, substantial employment opportunities are generated from innovation activities. Shao and Ma (2001) believe that high-tech industries facilitate the flow of production factors into those industries with higher productivity, thereby improving the efficiency of factor allocation.

In this paper, we attempt to employ the social accounting matrix (SAM) and multiplier decomposition method to inspect the driving effects of high-tech industries on various sectors of Chinese national economy. Based on the driving mechanism and data description, the fourth part is the analysis of the driving effects of high-tech industries on national economy, mainly the effects on various industries, factors and residents; in the fifth part, we study the

[2] In this article, the so-called "Non-production workers" are those "White Collars", a term referring to those practitioners who are not engaged in production and manufacturing activities.

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conduction paths of high-tech industries' driving effects on national economy based on the SAMs and structural path analysis; the last part is the conclusions.

2. Mechanism of Driving Effects of High-Tech Industry On National Economy

Featuring high permeability, high-tech industry exerts considerable driving effects on various sectors of national economy. In this part, we present theoretical explanations for the driving effects of high-tech industry on other industries, factors and residents.

As to various industries, promotinging effects of high-tech can be accomplished mainly through following three paths: the first one is the inter-industry forward and backward linkage. The output growth of high-tech industry is dependent on the consumption of products from other industries, while the final outputs of high-tech industry are also acted as intermediary products into the production processes of other industries. Therefore, the output growth of high-tech industry increases the demands for products from various industries on one side, and elevates the supplies for them on the other side. The second path lies in the fact that development of high-tech industry can promote the technological advancement and proceed to transform the traditional industrial chains, reduce the manufacturing costs of products, and enhance the marginal revenues of products through technical diffusion or spillover. Technological advancement could also continuously propel the production specialization across various industries and facilitate the development of new products. The third path is that the progress of high technology may optimize the factor allocation so that factors will be directed to flow into those industries with higher productivity. Meanwhile, technical advancement or progress will drive labor productivity and capital utilization efficiency, and thus improve the production efficiency in various industries.

Influences of high-tech industry on factors are mainly manifested in terms of their quantity and quality improvement. The growth of high-tech industry will increase the demand for labor, especially the need for scientific researchers and human capital. However, in the event that high-tech industries develop to a certain degree, where demands arising from such industries for labor tend to be stabilized, then transformation of traditional industries by high technologies is gradually emerging. In other words, new machinery and equipment adopted in traditional industries elevate labor productivity. Meanwhile, high-tech applications partially achieve the replacement of labor with capitals, so that driving effects of high-tech industry on labor factors may somewhat lessen. At the same time, high-tech industries can also enhance the marginal revenue of capitals. For example, development of high-tech industries will promote the technological progress, which retroacts on the law of diminishing marginal revenue of capital, so that the marginal revenue curve of capital changes and productivity of capital stock enhances.

For residents, the influences of high-tech industry are mainly achieved through their effects on factors. Increased demands of high-tech industry for labor and capital factors give rise to the increased income of residents. Applications of high technology in agriculture facilitate the relocation and employment of peasants, and contribute to the amelioration of rural infrastructure as well as agricultural equipments, thereby propelling the growth of rural residents' income. Comparatively, labor costs of urban residents are higher, and urban residents own much more capitals. Therefore, driving effects of high-tech industry on the

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income of urban residents shall be greater than on those of rural residents.

In addition to the above effects, advancements of high-tech industries still genarate a variety of indirect driving effects on national economy. For example, development of high-tech industry can either support the secondary industry by driving the growth of service industry, or increase the income of residents by expanding the demands for labor. And then high technology proceeds to influence the structure of consumption of residents, as well as their demands for products in various industries and eventually the output growth of economy.

3. Data Source and Method Selection

In the study of relationship among high-tech industries, other industrial sections and the remaining sectors of national economy, both IO (Input-Output) Table and SAM (Social Accounting Matrix) are indispensable analysis tools. However, the IO table only includes the information of industrial sections, and therefore, it cannot be used to analyze the effects of high-tech industries on other institutions of national economy. The SAM can unify the IO table with macroeconomy in one framework, thereby thoroughly reflecting the linkages among all sectors in national economy. Based on the perspective of external shock, it is possible to study the effects arising from the impacts of high-tech industries on other industrial departments, factors or residents through the multiplier decomposition of SAM. Additionally, we may adopt the structural path method of SAM to identify the conduction paths of high-tech industries' effects on national economy, as well as the characteristics of each path.

Based on the year 2002 and 2007 China IO Tables, this paper relies on the high-degree consolidation of sectors to gain 4×4 IO tables concerning primary industry, secondary industry, tertiary industry and high-tech industry. On the basis of merged IO tables, the SAMs of China in the year 2002 as well as the year 2007 are tabulated[3].

According to the SAMs, we set the production activity account (primary industry, secondary industry, tertiary industry and high-tech industry), factor account (labor, capital) and resident account (rural residents and urban residents) as the endogenous accounts. The business account, government account, capital account, stock account and external account are regarded as the exogenous accounts. Then we obtain the average expenditure propensity matrix $\boldsymbol{A}_n$ through dividing each element in the endogenous accounts by the aggregate value in the column in which it exists. The $\boldsymbol{A}_n$ is shown in Equation (1):

$$\boldsymbol{A}_n = \begin{bmatrix} \boldsymbol{A}_{11} & \boldsymbol{0} & \boldsymbol{A}_{13} \\ \boldsymbol{A}_{21} & \boldsymbol{0} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{A}_{32} & \boldsymbol{0} \end{bmatrix}, \tag{1}$$

[3] The IO tables are consolidated with reference to the method proposed by Pan et al.(2004). The SAM applied in this paper involves 13 sectors: Activity Account (Primary Industry, Secondary Industry, Tertiary Industry, High-Tech Industry), Factor Account (Labor, Capital), Resident Account (Rural Residents, Urban Residents), Business Account, Government Account, Capital Account, Stock Account and External Account. Preparation of social account matrix is made with reference to the method proposed by Wang et al. (2008). Due to the limitation of page, we do not list the IO tables and Social Accounting Matrix, which can be requested from authors whenever required.

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where, the subscripts 1, 2, 3 refer to production activity sector, factor sector and resident sector, respectively.

On the basis of $\boldsymbol{A}_n$, it is possible to obtain the account multiplier matrix $\boldsymbol{M}_a$, $\boldsymbol{M}_a=(\boldsymbol{I}-\boldsymbol{A}_n)^{-1}$. By derivation, $\boldsymbol{M}_a$ can be decomposed into $\boldsymbol{M}_{a1}$, $\boldsymbol{M}_{a2}$ and $\boldsymbol{M}_{a3}$[4]:

$$\boldsymbol{M}_a = \boldsymbol{M}_{a3}\boldsymbol{M}_{a2}\boldsymbol{M}_{a1}, \tag{2}$$

here,

$$\boldsymbol{M}_{a1}=\begin{bmatrix}(\boldsymbol{I}-\boldsymbol{A}_{11})^{-1} & \boldsymbol{0} & \boldsymbol{0}\\ \boldsymbol{0} & \boldsymbol{I} & \boldsymbol{0}\\ \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{I}\end{bmatrix},\quad \boldsymbol{M}_{a2}=\begin{bmatrix}\boldsymbol{I} & (\boldsymbol{I}-\boldsymbol{A}_{11})^{-1}\boldsymbol{A}_{13}\boldsymbol{A}_{32} & (\boldsymbol{I}-\boldsymbol{A}_{11})^{-1}\boldsymbol{A}_{13}\\ \boldsymbol{A}_{21} & \boldsymbol{I} & \boldsymbol{A}_{21}(\boldsymbol{I}-\boldsymbol{A}_{11})^{-1}\boldsymbol{A}_{13}\\ \boldsymbol{A}_{32}\boldsymbol{A}_{21} & \boldsymbol{A}_{32} & \boldsymbol{I}\end{bmatrix},$$

$$\boldsymbol{M}_{a3}=\begin{bmatrix}(\boldsymbol{I}-(\boldsymbol{I}-\boldsymbol{A}_{11})^{-1}\boldsymbol{A}_{13}\boldsymbol{A}_{32}\boldsymbol{A}_{21})^{-1} & \boldsymbol{0} & \boldsymbol{0}\\ \boldsymbol{0} & (\boldsymbol{I}-\boldsymbol{A}_{21}(\boldsymbol{I}-\boldsymbol{A}_{11})^{-1}\boldsymbol{A}_{13}\boldsymbol{A}_{32})^{-1} & \boldsymbol{0}\\ \boldsymbol{0} & \boldsymbol{0} & (\boldsymbol{I}-\boldsymbol{A}_{32}\boldsymbol{A}_{21}(\boldsymbol{I}-\boldsymbol{A}_{11})^{-1}\boldsymbol{A}_{13})^{-1}\end{bmatrix},$$

among them $\boldsymbol{M}_{a1}$ is the transfer multiplier matrix representing the direct income flow in a certain endogenous account, such as the straightforward impacts of high-tech industry to tertiary industry in the production activity account; $\boldsymbol{M}_{a2}$ is the open-loop multiplier matrix, which stands for the circulation of income between endogenous accounts; while $\boldsymbol{M}_{a3}$, the closed-loop multiplier matrix, signifies the loop transfer of income stream in a certain endogenous account, where the starting point of income flow is the same as its closing end.

Furthermore, Equation (2) can be represented in the form of addition as shown in Equation (3):

$$\boldsymbol{M}_a = \boldsymbol{I}+(\boldsymbol{M}_{a1}-\boldsymbol{I})+(\boldsymbol{M}_{a2}-\boldsymbol{I})\boldsymbol{M}_{a1}+(\boldsymbol{M}_{a3}-\boldsymbol{I})\boldsymbol{M}_{a2}\boldsymbol{M}_{a1} = \boldsymbol{I}+\boldsymbol{T}+\boldsymbol{O}+\boldsymbol{C}, \tag{3}$$

where $\boldsymbol{T}$ is the transfer effect, $\boldsymbol{O}$, $\boldsymbol{C}$ are the open-loop and closed-loop effect.

4. Driving Effects of High-Tech Industry On National Economy

4.1 Driving Effects of High-Tech Industry On Various Industrial Sectors

We conduct the SAM-based multiplier decomposition to evaluate the impact effects of high-tech industry on other sectors. In this part, how the shocks of high-tech industry can affect various industries will be first reviewed, and how such shocks impact other sectors of national economy is going to be analyzed in the second part of this section.

Results of SAM multiplier decomposition calculated by adopting the social accounting matrix in 2002 and 2007 are shown in Table 1.

[4] For simplicity, the process of derivation is not listed in this paper.

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Table 1. Effects of shock from High-Tech Industry on Other Industries

The year 2002					
Starting Point	Closing end	Net effect($\boldsymbol{M_a}$–$\boldsymbol{I}$)	Transfer effect($\boldsymbol{T}$)	Open-loop effect($\boldsymbol{O}$)	Closed-loop effect($\boldsymbol{C}$)
High-tech industry	Primary Industry	0.149	0.051	0	0.098
	Secondary Industry	0.861	0.556	0	0.305
	Tertiary Industry	0.444	0.221	0	0.223
The year 2007					
Starting point	Closing end	Net effect($\boldsymbol{M_a}$–$\boldsymbol{I}$)	Transfer effect($\boldsymbol{T}$)	Open-loop effect($\boldsymbol{O}$)	Closed-loop effect($\boldsymbol{C}$)
High-tech industry	Primary Industry	0.100	0.053	0	0.047
	Secondary Industry	0.919	0.630	0	0.289
	Tertiary Industry	0.371	0.199	0	0.172

As in table 1, the impact effects of high-tech industry on other industries transfer in the production activity account internally; the open-loop effect $\boldsymbol{O}$ is unexceptionally equal to 0. The year 2002 witnesses the significant impacts from high-tech industry on secondary industry. An injection of 100 units into high-tech industry results in an increase of 86.1 units in the output of secondary industry, including the transfer effect of 55.6 units and closed-loop effect of 30.5 units. The transfer effect is greater than the closed-loop effect apparently. As such, influence of high technology on secondary industry is relatively direct. Meanwhile, in the year 2002, a shock of 100 units from high-tech industry leads to a rise of 44.4 units in the output of tertiary industry, accounting for about 50% of the yield of secondary industry. Besides, transfer effect (0.221) is essentially equal to closed-loop effect (0.223) for tertiary industry, signifying that direct effect of high-tech industry on tertiary industry is roughly equivalent to the indirect influence.

Driving effect of high-tech industry on secondary industry is greater than on tertiary industry because applications of high technology in secondary industry, especially in manufacturing industry can effectively enhance productivity and gain economic benefits. Nevertheless, driving effects of high-tech industry on tertiary industry are not fully displayed. Whether high technology can facilitate the further development of tertiary industry depends on the continuous applications of high technology in service industry and constant progress of knowledge intensive service industry.

In the year 2002, 100 units shocks from high-tech industry bring about 14.9 units output growth of primary industry, made up by the transfer effect (5.1 units) and the closed-loop effect (9.8 units). The fact that closed-loop effect is greater than transfer effect suggests that there is comparatively less linkage between high-tech industry and primary industry. That is to say, high-tech industry can lead to few direct and complete consumption of products from primary industry, so that the driving effect of the former on the latter is limited as well.

The greatest brunt from high-tech industry to secondary industry comes out in the year

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2007, where 100 units growth of high-tech industry create 91.9 units increase in secondary industry, composed by the transfer effect of 63 units and a closed-loop effect of 28.9 units. As compared with the situation in 2002, net impact effect and transfer effect of high-tech industry on secondary industry are both somewhat increased. Influences of high technology on secondary industry are more direct and significant, with further intensified infiltration into secondary industry.

For tertiary industry and primary industry, as in table 1, the net effects of high-tech industry on them are 0.371 and 0.100 in the year 2007, respectively. From the year 2002 to 2007, driving effects of high-tech industry are slightly reduced on both above industries. Service industry can be cited here as the example, in which applications from such emerging service industries as new technology consultation or mobile network services still remain unpopular in China, so continuous expansion of high technology are still required for a period to promote their output growth. It should be pointed out that transfer effect (0.199) of high-tech industry is greater than its closed-loop effect (0.172) in tertiary industry which is similar to primary industry with transfer effect (0.053) and closed-loop effect (0.047). The result suggests that driving effects of high-tech industry are more direct on tertiary industry and primary industry.

4.2 Driving Effects of High-Tech Industry on Other Sectors of National Economy

Besides all kinds of industries, high-tech industry acts as driving effects on other sectors of national economy as well. In this section, we will focus on the impact effects on labor factor, capital factor, rural and urban residents from high-tech industry. Results of SAM multiplier decomposition for high-tech industry vs. other sections of China's economy acquired after calculation by adopting the social accounting matrix in the year 2002 and 2007 are listed in Table 2.

Table 2. Effects of shock from High-Tech Industry to Other Sectors of National Economy

The year 2002					
Starting point	Closing end	Net effect($\boldsymbol{M_a}$–$\boldsymbol{I}$)	Transfer effect($\boldsymbol{T}$)	Open-loop effect($\boldsymbol{O}$)	Closed-loop effect($\boldsymbol{C}$)
High-tech industry	Labor Factor	0.341	0	0.210	0.131
	Capital Factor	0.280	0	0.197	0.083
	Rural Resident	0.128	0	0.079	0.049
	Urban Resident	0.244	0	0.153	0.091
The year 2007					
Starting point	Closing end	Net effect($\boldsymbol{M_a}$–$\boldsymbol{I}$)	Transfer effect($\boldsymbol{T}$)	Open-loop effect($\boldsymbol{O}$)	Closed-loop effect($\boldsymbol{C}$)
High-tech industry	Labor Factor	0.237	0	0.163	0.074
	Capital Factor	0.282	0	0.205	0.077
	Rural Resident	0.079	0	0.054	0.025
	Urban Resident	0.179	0	0.123	0.055

As in table 2, the influences of high-tech industry on other sectors of national economy circulate among various accounts, so the transfer effect $\boldsymbol{T}$ is unexceptionally 0. In the year 2002, a shock of 100 units from high-tech industry results in an increase of 34.1 units in labor factor income. The advancement of high-tech industry can provide more employment

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opportunities, and facilitate the technical labor skills in traditional industries to be enhanced via skills training.

With respect to capital factor, in the year 2002, the net effect of high-tech industry on capital is 0.280 with an open-loop effect of 0.197 and a closed-loop of 0.083. High marginal revenue generates from the capitals invested in high-tech industry. Moreover, transformation of equipment with high technology may also swiftly enhance the productivity and in turn, increase the capital income quickly. Yet, driving effect of high-tech industry is less on the increase of capital income than on the growth of labor factor revenue, indicating to a certain extent that most industries in China still remain the style of labor intensive.

Influences of high-tech industry on residents are mainly achieved through factors' income. In the year 2002, 100 units exogenous demand of high-tech industry could bring about 12.8 units growth in the earning of rural residents. The applications of high technology promote the relocation and employment of peasants as well as the increase of their wage income, and are beneficial to the improvement of agricultural mechanization. In terms of effects on urban residents, the results in table 2 show that the net impact of high-tech industry on urban residents is 0.244. Since the labor prices of urban residents may be higher and urban residents possess more capitals, the effects of high-tech industry are far greater on the income of urban residents than on that of rural residents.

In the year 2007, a shock of 100 units from high-tech industry gives rise to a growth of 23.7 units in the labor factor income. As compared with the results in 2002, driving forces of high-tech industry on labor factors slightly decrease. When a high-tech industry is developed to a certain degree, its demand for labor will be also relatively stabilized that may promote the partial substitution of labor by capital. On the whole, however, high-tech industry has remarkably contributed to the growth of labor income.

Regarding capital element, the tabel 2 displays that net effect of high-tech industry is 0.282, including open-loop effect (0.205) and closed-loop effect (0.077). As we can see, both the driving effect and direct effect of high-tech industry on capital factors are intensified. Furthermore, progress of high-tech industry could constantly increase demands for capitals. In 2007, driving force of high-tech industry on capital factor is greater than on labor factors, so that high-tech industry plays a positive role in the shift of traditional industries from being labor intensive to capital intensive in China.

The calculation results in table 2 also manifest that the propelling impacts of high-tech industry obviously lessen on both the income of rural and urban residents from the year 2002 to 2007. The cause is apparent. Because labor factor serves as a main component of residents' income, high-tech industry has decreased impluse effects on labor factor and then exerts lower influence on residents.

To further unveil the mechanism of driving effects, in the next part, we employ the structural path analysis method to study through what channels and to what degree the shock of high-tech industry could affect all sectors of national economy.

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5. Conduction Paths of Effects of High-Tech Industry on National Economy

5.1 Conduction Paths of Effects of High-Tech Industry on Various Industrial Sectors

Table 3 shows the structural conduction path of high-tech industry's effects on various industries, which is calculated on the basis of social accounting matrix in the year 2002. Due to a great variety of paths, only those main paths are listed in this paper.

The overall effect (*IG*) is the value of elements in the 3rd column of the account multiplier matrix ($\boldsymbol{M}_a$) which represents the comprehensive effects of high-tech industry on other sectors. Direct effect of one path (*ID*) is the product of element values of junction points that this path passes through in the average expenditure propensity matrix ($\boldsymbol{A}_n$). The path multiplier (*Mp*) is the ratio between the value of determinant obtained after the deletion of various junction points in the path and the value of $|I-\boldsymbol{A}_n|$. In addtion, the full effect of one path (*IT*) is the sum of all direct effects and indirect effects on this path, and satisfies $IT = ID \times Mp$. The reciprocal of *Mp* signifies the proportion of direct effect in the complete effect. The greater the value of $1/Mp$, the more the proportion of direct effect, and the faster the speed of conduction of the shock. [5]

In the year 2002, the impacts of high-tech industry on primary industry are mainly achieved through the path "High-tech industry→Secondary industry→Primary Industry" which transmits 29.366% of the overall effect. High-tech industry propels the output growth of secondary industry, and in turn increases the demand for agricultural products and materials, thereby driving the development of primary industry. However, as the multiplier of this path is 4.715, the proportion of direct effect is relatively small and the conduction may be quite slow. Additionally, direct applications of high technology largely facilitate the development of primary industry, so that such applications account for 10.153% of the overall effect. Meanwhile, the multiplier of this path is 2.118, where the conduction is particularly fast. High-tech applications have enhanced the productivity of primary industry swiftly.

From another perspective, as is shown in table 3, high-tech industry promotes the income increase of rural as well as urban residents through affecting labor factors and eventually achieves their great effects on primary industry. As stated above, demands for labor continuously increase with the development of high-tech industry so that income of residents grows, and in turn, consumption of agricultural products by these residents gradually augments. The comprehensive result is the output growth of primary industry.

In regard to secondary industry, in the year 2002, the effect conducted via the "High-Tech Industry→Secondary Industry" path occupies 72.278% of the overall effect, suggesting that infiltration of high-tech industry on secondary industry is mainly accomplished in the direct applications of high technology. Whereas the multiplier of this path is 3.491, indicating that there is a long time lag in this conduction path. That is to say, certain time lag would be requisite for high technology to be applied in the transformation and upgrading of equipment in secondary industry.

[5] For detailed explanations, Wang Qiwen, Li Shantong, Social Accounting Matrix: Principles, Methods and Applications, Beijing: Tsinghua University Press, 2008: 138-141.

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Table 3. Conduction Paths of Effects of High-Tech Industry on Various Industrial Sectors (2002)

Starting of path (*i*)	Ending of path （*j*)	Overall effect (*IG*)	Basic paths (*i*→*j*)	Direct effect (*ID*)	Path multiplier (*Mp*)	Full effect (*IT*)	*IT*/*IG* (%)
High-Tech Industry	Primary Industry	0.149	High-Tech Industry →Primary Industry	0.007	2.118	0.015	10.153
			High-Tech Industry →Secondary Industry →Primary Industry	0.009	4.715	0.044	29.366
			High-Tech Industry →Tertiary Industry →Primary Industry	0.001	3.408	0.004	2.836
			High-Tech Industry→ Labor→Rural Resident →Primary Industry	0.006	2.659	0.015	10.230
			High-Tech Industry→ Labor→Urban Resident →Primary Industry	0.004	2.702	0.011	7.312
	Secondary Industry	0.861	High-Tech Industry →Secondary Industry	0.178	3.491	0.622	72.278
			High-Tech Industry →Tertiary Industry →Secondary Industry	0.016	5.073	0.081	9.427
			High-Tech Industry→ Labor→Rural Resident →Secondary Industry	0.005	4.404	0.023	2.677
			High-Tech Industry→ Labor→Urban Resident →Secondary Industry	0.009	4.446	0.040	4.695
			High-Tech Industry→ Capital→Urban Resident →Secondary Industry	0.002	4.018	0.007	0.867
	Tertiary Industry	0.444	High-Tech Industry →Tertiary Industry	0.077	2.452	0.189	42.473
			High-Tech Industry →Secondary Industry →Tertiary Industry	0.021	5.073	0.108	24.224
			High-Tech Industry→ Labor→Rural Resident →Tertiary Industry	0.007	2.943	0.022	4.915
			High-Tech Industry→ Labor→Urban Resident →Tertiary Industry	0.012	2.960	0.037	8.279
			High-Tech Industry→ Capital→Urban Resident →Tertiary Industry	0.003	2.718	0.007	1.552

Besides, high-tech industry can propel the development of tertiary industry and in turn, provide impetus to the output growth of secondary industry. According to table 3, the proportion of this path only accounts for 9.427% of the overall effect with a path multiplier as 5.073. There is a long way ahead for high-tech industry to achieve the simultaneously driving

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effects on both secondary and tertiary industries. On account of the analysis above, we conclude that high-tech industry exerts great effect on secondary industry, but such effect requires a long time lag.

However, overall characteristics of high-tech industry's effects on tertiary industry run completely contrary to secondary industry. In the year 2002, there are slight influences of high-industry on tertiary industry, but with a short time lag and swift conduction. The proportion of the overall effect conducted via the most direct "High-Tech Industry→Tertiary Industry" path is 42.473%, and that of the overall effect conducted through secondary industry as the medium is 24.224%, totaling up to 66.697%. The multiplier of the direct path is 2.452, but that of the path with secondary industry as the medium is 5.073. Relative to secondary industry, tertiary industry has shorter industrial chains, where high-tech applications can more rapidly transform such industrial chains, facilitate the professional specialization of service industry and enhance the level of marketization.

Development and increased efficiency of high-tech service industry can also encourage a lot of traditional businesses to outsource their internal affairs to professional service industry sectors, thereby accomplishing the gradual shift of services from internalization to externalization. In addition, high-tech industry can also affect the income of urban residents through labor factors, and then eventually achieves the influences on tertiary industry. After the income of urban residents grows, demands for services will substantially increase which proceed to facilitate the output growth of tertiary industry.

Compared with 2002, no great variations in the conduction paths of high-tech industry towards various industries arise. The main change is in the slight increase of the overall effect of high-tech industry on various industries transmitted via direct conduction paths. We present important conduction paths of high-tech industry on other industries calculated on the basis of 2007 SAM in Table 4.

In the year 2007, the "High-tech industry→Secondary industry→Primary industry" path delivers 34.499% of the overall effect of high-tech industry on primary industry; the "High-tech industry→ Primary industry" path transmits 24.172% of the overall effect. The impacts are slightly increased in both paths as compared to those in 2002, signifying that high-tech technologies are playing a growingly intensified role in agricultural development. The multiplier of the direct path is 2.101, where the conduction is faster than in 2002.

As to secondary industry, the conduction ratio of the "High-tech industry→Secondary industry" path is 73.491%, up by 1.21 percent from the year 2002 to 2007. Applications of high technology further contribute to the elevation of productivity in secondary industry, yet the multiplier of this path is enlarged from 3.491 to 4.294. It shows that deep processing of industrial products have led to the elongation of industrial chains, and more time is needed to complete the transformation of industrial chains with high technology. The multiplier of the "High-tech industry→Tertiary industry→Secondary industry" path increases from 5.073 in the year 2002 to 5.992 in 2007. Therefore, effects of high-tech industry on secondary industry are strengthened with a slower speed.

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Table 4. Conduction Paths of Effects of High-Tech Industry on Various Industrial Sectors (2007)

Starting of path (*i*)	Ending of path (*j*)	Overall effect (*IG*)	Basic Paths (*i*→*j*)	Direct effect (*ID*)	Path multiplier (*Mp*)	Full effect (*IT*)	*IT*/*IG* (%)
High-Tech Industry	Primary Industry	0.100	High-Tech Industry →Primary Industry	0.011	2.101	0.024	24.172
			High-Tech Industry →Secondary Industry →Primary Industry	0.006	5.434	0.034	34.499
			High-Tech Industry →Tertiary Industry →Primary Industry	0.001	3.188	0.003	2.683
			High-Tech Industry→ Labor→Rural Resident →Primary Industry	0.002	2.547	0.006	5.862
			High-Tech Industry→ Labor→Urban Resident →Primary Industry	0.002	2.591	0.005	4.915
	Secondary Industry	0.919	High-Tech Industry →Secondary Industry	0.157	4.294	0.675	73.491
			High-Tech Industry →Tertiary Industry →Secondary Industry	0.013	5.992	0.080	8.750
			High-Tech Industry→ Labor→Rural Resident →Secondary Industry	0.004	5.113	0.019	2.028
			High-Tech Industry→ Labor→Urban Resident →Secondary Industry	0.009	5.160	0.047	5.078
			High-Tech Industry→ Capital→Urban Resident →Secondary Industry	0.001	4.839	0.006	0.692
	Tertiary Industry	0.371	High-Tech Industry →Tertiary Industry	0.070	2.423	0.168	45.395
			High-Tech Industry →Secondary Industry →Tertiary Industry	0.013	5.992	0.080	21.544
			High-Tech Industry→ Labor→Rural Resident →Tertiary Industry	0.005	2.815	0.014	3.649
			High-Tech Industry→ Labor→Urban Resident →Tertiary Industry	0.012	2.829	0.034	9.039
			High-Tech Industry→ Capital→Urban Resident →Tertiary Industry	0.002	2.666	0.005	1.237

On tertiary industry, the overall effect of high-tech industry as well as the path multiplier suggests that the influence of high-tech industry is reduced, but the time lag is further shortened. This is chiefly in that scientific service industries or knowledge intensive

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service businesses closely associated with high technologies still remain unpopular in China. However, once applied in tertiary industry, high technology can well produce economic benefits swiftly. For instance, the upgrading of service by high-tech outcomes may enhance service quality, reduce service costs and uplift the service level. The proportion of the "High-tech industry→Tertiary industry" path in the overall effect is 45.395%, up by 2.922 percent in comparison with the consequences in the year 2002.

5.2 Conduction Paths of Effects of High-Tech Industry on Other Sectors of National Economy

The structural paths of high-tech industry' impacts on other sectors in 2002 are shown in Table 5.

In terms of the results in table 5, the evolution of high-tech industry effectively promotes the growth of employment in the year 2002. In view of the overall effect transmitted via various conduction paths on labor, high-tech industry mainly contributes to the growth of practitioners in high-tech industry (35.749%) and subsequently, the employment's increase in secondary and tertiary industries (24.191% and 15.546%, respectively). However, high-tech industry imposes limited effect on primary industry in the aspect of employment. Advances of high technologies can create a great number of new employment opportunities in high-tech industry, enhance the output growth of secondary or tertiary industry and in turn stimulate the growth of demand for labor in both industries.

Proportions of capital accumulation in various industries are essentially similar to the ratios of employment growth stimulated by high-tech industry. Three conduction paths in the year 2002 show that proportions of the overall effect conducted from high-tech industry on capital accumulation of its own, secondary industry, tertiary industry are 36.792%, 21.403% and 13.118%. Advancement of high-tech industry requires continuous research and updating of technologies, so that higher capital factors are always desirable. Such capital input as added and updated equipment is also in need for the output growth of secondary industry. By contrast, growth in the output of tertiary industry calls for relatively less capital. As stated above, promoting effects of high-tech industry on the output growth of tertiary industry have not been fully emerging; hence the progress of capital accumulation in tertiary industry is comparatively sluggish.

When income of rural residents is concerned, in the year 2002, impacts of high-tech industry on the income of rural residents are mainly achieved through the path of "High-tech industry→Labor→Rural residents" which transmits 35.147% of the overall effect. High-tech industry could promote the demand for rural labor and therefore increase the marginal returns for the labor of rural residents and the income of them. Moreover, high-tech industry accelerates the relocation of rural labor resources and effectively elevates the income of rural residents.

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Table 5. Conduction Paths of Effects of High-Tech Industry on Other Sectors of National Economy (2002)

Starting of path (*i*)	Ending of path (*j*)	Overall effect (*IG*)	Basic Paths (*i*→*j*)	Direct effect (*ID*)	Path multiplier (*Mp*)	Full effect (*IT*)	*IT*/*IG* (%)
High-Tech Industry	Labor	0.341	High-Tech Industry →Labor	0.056	2.159	0.122	35.749
			High-Tech Industry →Primary Industry →Labor	0.003	2.655	0.008	2.483
			High-Tech Industry →Secondary Industry →Labor	0.019	4.400	0.082	24.191
			High-Tech Industry →Tertiary Industry →Labor	0.018	2.940	0.053	15.546
	Capital	0.280	High-Tech Industry →Capital	0.070	1.463	0.103	36.792
			High-Tech Industry →Primary Industry →Capital	0.001	2.169	0.001	0.481
			High-Tech Industry →Secondary Industry →Capital	0.017	3.540	0.060	21.403
			High-Tech Industry →Tertiary Industry →Capital	0.015	2.474	0.037	13.118
	Rural Resident	0.128	High-Tech Industry→ Labor→Rural Resident	0.021	2.164	0.045	35.147
			High-Tech Industry→ Capital →Rural Resident	0.001	1.792	0.001	0.849
			High-Tech Industry→ Primary Industry→ Labor→Rural Resident	0.001	2.659	0.003	2.440
			High-Tech Industry→ Secondary Industry→ Labor→Rural Resident	0.007	4.404	0.030	23.760
			High-Tech Industry→ Tertiary Industry→ Labor→Rural Resident	0.007	2.943	0.020	15.264
	Urban Resident	0.244	High-Tech Industry → Labor→Urban Resident	0.036	2.205	0.079	32.173
			High-Tech Industry → Capital→Urban Resident	0.007	1.879	0.014	5.601
			High-Tech Industry→ Primary Industry→ Labor→Urban Resident	0.002	2.702	0.005	2.228
			High-Tech Industry→ Secondary Industry→ Labor→Urban Resident	0.012	4.446	0.053	21.547
			High-Tech Industry→ Tertiary Industry→ Labor→Urban Resident	0.011	2.960	0.034	13.796

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As we can see, the percentage conducted via the “High-tech industry→Capital→Urban residents” path is 5.601% with a path multiplier as 1.891. That is to say high-tech industry promotes the income increase of urban residents quickly through their capital accumulation. In accord with the previous conclusions, high-tech industry can be a greater propeller on the income of urban residents than on that of rural residents.

Based on the SAM of 2007, the conduction paths of high-tech industry’ impacts on other sectors of national economy are computed and shown in Table 6.

The consequences in table 6 display that impacts of high-tech industry on secondary and tertiary industries are lessened in the year 2007. Transformation and upgrading of traditional equipment result in partial substitution of labor with capitals. Meanwhile, the proportion of the overall effect conducted via the “High-Tech Industry→Primary Industry →Labor” path is amplified from 2.483% in the year 2002 to 6.52% in the year 2007. Promotion of agricultural equipment in modern agriculture by high-tech industry speeds up the growth of agricultural output and the demand for agricultural labor.

By comparing with the case in 2002, high-tech industry’s promotion of its own capital accumulation is decreased and the percentage in the overall effect is reduced from 36.792% to 32.712%, down by 4.08 percent. On the contrary, there are 2.459 and 2.923 percents’ increases in the overall effect that high-tech industry transmits towards the capital accumulation in secondary and tertiary industries. Along with the growth of high-tech industry, physical capital’s importance is lessened, whereas human capital investment becomes the deterministic force dominating the advancement of high-tech industry.

Moreover, relative to the situation in the year 2002 and in conjunction with the conduction paths of high-tech industry on labor, driving effects of high-tech industry on its own, secondary and tertiary industries’ demands for labor factors are reduced. That triggers the decreased income of labor factor and earning of rural or urban residents. However, development of high-tech industry boosts the demand of primary industry for labor, so there are increases of 3.944 and 3.723 percents for the proportion in the overall effect conducted via the “High-tech industry→Primary industry→Labor→Rural resident” way and the “High-tech industry→Primary industry→Labor→Urban resident” path.

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Table 6. Conduction Paths of Effects of High-Tech Industry on Other Sectors of National Economy (2007)

Starting end of path (*i*)	Closing end of path（*j*)	Overall effect (*IG*)	Basic Paths (*i*→*j*)	Direct effect (*ID*)	Path multiplier (*Mp*)	Full effect (*IT*)	*IT*/*IG* (%)
High-Tech Industry	Labor	0.237	High-Tech Industry→Labor	0.040	2.124	0.084	35.427
			High-Tech Industry→ Primary Industry→Labor	0.006	2.543	0.015	6.520
			High-Tech Industry→ Secondary Industry→Labor	0.011	5.109	0.055	23.025
			High-Tech Industry→ Tertiary Industry →Labor	0.012	2.814	0.033	13.704
	Capital	0.282	High-Tech Industry →Capital	0.059	1.567	0.092	32.712
			High-Tech Industry→ Primary Industry →Capital	0.0003	2.152	0.001	0.265
			High-Tech Industry→ SecondaryIndustry→Capital	0.015	4.349	0.067	23.862
			High-Tech Industry→ Tertiary Industry →Capital	0.019	2.440	0.045	16.041
	Rural Resident	0.079	High-Tech Industry →Labor→Rural Resident	0.013	2.128	0.027	34.695
			High-Tech Industry →Capital→Rural Resident	0.0004	1.782	0.001	0.831
			High-Tech Industry→ Primary Industry→ Labor→Rural Resident	0.002	2.547	0.005	6.384
			High-Tech Industry→ Secondary Industry→ Labor→Rural Resident	0.003	5.113	0.018	22.530
			High-Tech Industry→ Tertiary Industry→ Labor→Rural Resident	0.004	2.815	0.011	13.405
	Urban Resident	0.179	High-Tech Industry →Labor→Urban Resident	0.027	2.166	0.058	32.373
			High-Tech Industry →Capital→Urban Resident	0.004	1.954	0.008	4.241
			High-Tech Industry→ Primary Industry→ Labor→Urban Resident	0.004	2.591	0.011	5.951
			High-Tech Industry→ Secondary Industry→ Labor→Urban Resident	0.007	5.160	0.037	20.840
			High-Tech Industry→ Tertiary Industry→ Labor→Urban Resident	0.008	2.829	0.022	12.347

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6. Conclusions

Based on the SAM of China in the year 2002 and 2007, we adopted the multiplier decomposition approach to study the driving effects of high-tech industry on various industries. The results show that high technologies can produce the most and substantial effects on secondary industry with growingly intensified influences, yet the driving effects of high-tech industry on tertiary industry have not been fully displayed. Besides, we probe into the shocks of high-tech industry on the demand for factors and income of residents. More job opportunities can be created as a result of growth of high-tech industry, while there is a tendency that capitals take place of labor. Promoting effects of high-tech industry are less on capital demands than on labor. Also, impacts of high-tech industry are far greater on the income of urban residents than on that of rural residents.

Structural path analysis can be used to further unveil the mechanism that high-tech industry's driving effects on all sectors of national economy. The conclusions are that high-tech industry can play a growingly intensive role in modern agriculture. High-tech industry also has very powerful direct influences on the output growth of secondary industry, but there may be a long time lag. On the contrary, impacts are relatively less on tertiary industry, but the conduction is swift.

Analysis of conduction paths from high-tech industry to the remaining sectors of national economy manifests that high-tech industry effectively accelerates the growth of its own employment, and that in secondary and tertiary industries. However, the substitution of labor with capital is a small obstacle of high-tech industry on employment growth. Particularly, high-tech industry's promotion on the output of primary industry can lead to continuously increasing demand for labor force. From the year 2002 to 2007, the weakened impacts of high-tech industry on demands for labor bring the reduced driving effect to the income of residents.

Due to the critical function of high-tech industry, efforts shall be made to broaden the application channels for high technologies, facilitate the conversion of high-tech industry outcomes and increase the demand for high-tech products. On that basis, we can enhance the digestion or assimilation of high technologies by traditional industries, transform the traditional industrial chains and elevate productivity in major sectors. Specifically, in terms of rural infrastructure construction as well as renewal of agricultural equipment, we ought to take advantage of high technologies in the development of modern agriculture and in supply increase of agricultural products. In the end, factors could be re-allocated or guided into such sectors as high-tech industry, service industry and high-end manufacturing industry with higher efficiency.

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