## Contributions of FIEs to China's Economy Using an Input-Output Model Capturing Processing Trade with Ownership Distinction

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**Abstract:**

Since China's opening policy, low-cost labor force in China, preferential policies and China's huge potential market are major drivers pushing foreign direct investment (FDI) flowing into China. FDI has greatly promoted China's economic growth in the past three decades. Since 1993, China has become the second largest recipients of FDI in the world. Most of the inward FDI in China are used to set up foreign invested enterprises (FIEs), data from China's Ministry of Commerce show that there has been more than 740 thousands FIEs established in China by April 2012. FIEs have become an important component of the Chinese economy.

To shed light on the different roles of foreign invested enterprises (FIEs) and domestic-owned enterprises (DOEs) in China's economy, in this paper we proposes a non-competitive input-output model with distinction of FIEs and DOEs capturing processing trade in China's economy. The model divides China's economy into six parts in order to capture the differences in production technology & structure between DOEs and FIEs, as well as between processing exports and non-processing exports. Based on the above model, we compile the special input-output table of China for 2007, conduct empirical analysis of the contribution by DOEs & FIEs to China's economy and make a rough estimate of the contribution of EU FDI into China.

**Keywords:** Six-portion input-output model; ownership; trade pattern; GDP;

### 1. Introduction

Since the middle 1980s, China has achieved extraordinary economic growth, with an average annual growth rate of 9.9%, according to the official data from National Bureau of Statistics of China (NBS, 2012). China's economic achievement seems to owe much to the adoption of radical initiatives in encouraging inward foreign investment. Since China's opening policy, the Chinese government desires to promote exports through absorbing foreign direct investment (FDI) to China (Zhang & Song, 2001). The low cost of human resources and China's huge potential market further made China become a magnet for FDI. Accordingly, foreign capital has substantially flowed into China's manufacturing industries and is said to transform China into a 'factory to the world'. Since 1993, China has become the largest recipient of FDI among developing countries, and the globally second after the United States, with an annual growth rate of 17% in FDI from 1985 to 2011 (NBS, 2012). Most of the inward FDI in China is used to set up foreign-invested enterprises (FIEs)[1]. According to the Ministry of Commerce of China (MOFCOM), there has been more than 740 thousands FIEs approved to be established by April 2012. FIEs already have been important components of Chinese economy.

The Chinese economy comprises two distinct 'sub-economies' in terms of ownership: FIEs and domestic-owned enterprises (DOEs), both of which contribute considerably to China's economic growth. However, these two parts stand in sharp contrast to each other. For example, FIEs usually have obvious technical advantages, compared with technology levels of China (Zhou et al., 2002). Meanwhile, FIEs usually employ a small part of workforce, with much higher labor productivity than DOEs (Whalley & Xin, 2010). In addition, FIEs usually focus on exports, typically produce separate and distinct products designed abroad. Accordingly, it is expected that these two types of economies play very different roles in China's economy. An interesting question one may ponder is how different these two types of economies contribute to China's economy. It is an important issue because it will determine China's policy orientation. If FDI has minor or even a negative impact on the host economy, the host government will be motivated to implement policies to constrain future FDI inflow. But if the Chinese economy depends too heavily on FIEs, it may suggest that China's future rapid economic growth may not be sustainable, for example if one day FDI flows into other countries/regions is extremely in a large scale, China's economy will encounter severe difficulties. Existed literature has confirmed that FDI has significantly boosted China's trade performance and economic growth (Dees, 1998; Yao, 2006; Zhang & Felmingham, 2002). For example, Whalley & Xin (2010) documented that without the inward FDI, China's growth rate may have been around 3.4 percentage points lower in the last few years. However, the existed literature has not depicted the whole picture. On one hand, mostly they have ignored the important role of DOEs, that is, what is FIEs' contribution to China compared with that of DOEs. On the other hand, the present literature often focuses on the results at national level, while ignoring the remarkable variance of FIEs' role among individual industries. Accordingly, one essential purpose of this paper is to shed light on the respective role of FIEs and DOEs at both national level and industry level.

When looking at the other side of the coin, besides the remarkable discrepancy, FIEs and DOEs are closely interlinked. To some extent, FDI may bring new products and new technologies to the host country, and then domestic firms may benefit from FDI through personnel turnover, demonstration effects, and knowledge spillovers (Hu & Jefferson, 2002; Zhou et al., 2002; Cheung & Lin, 2004). However, the presence of FDI in a certain industry may also exert adverse effect on DOEs in that industry. By enjoying better technologies and lower production costs, FIEs may cut into the market share of DOEs. For example, Zhou et al. (2002) documents that DOEs in regions that attract more FDI or have a longer history of FDI

[1] In this paper, FIEs refers to three types of foreign-owned firms: wholly foreign-owned, equity joint venture and contractual joint venture.

tend to have higher productivity, while DOEs in industries that have more FDI or have a longer history of FDI tend to have lower productivity. However, literature always emphasizes on how the FIEs impact the DOEs, while ignoring that development of FIEs also partly depends on DOEs. In this paper, we will fill this gap by developing a new six-portion input-output (IO) model, which explicitly reflects the differences and interlinkages between FIEs and DOEs, as well as production type by ownership.

The remainder of the paper is organized as follows. Section 2 introduces the IO framework with distinction of both FIEs & DOEs, and production type. Section 3 describes the data sources used to construct the corresponding IO table. Then, section 4 provides the empirical results and their implications. In section 5, we further conduct a rough estimate of the contribution of FDI sourced from European Union (EU) to China's economy. Finally, section 6 concludes.

## 2. Methodology

IO model is a quantitative economic technique proposed by Wassily W. Leontief (1937), which depicts the complex interdependence among various industries or producers within a national economy or among different regional economies. To solve different practical problems, then various extended IO models has been deviated from the basic IO model in later studies, for example, hybrid IO model for energy. Based on IO model, we can compute the indexes, for example output, value-added and employment generated by a certain amount of final demand and its components (consumption, capital formation, export). When it comes specially to China, however, considerable evidences show that studies that fail to separate China's processing exports from its other productions (e.g., production for domestic use), will result in very biased estimates[2] (Dean et al.,2007; Koopman et al.,2008; and Pei et al., 2012). Fortunately, Chen *et al.* (2001) and Lau *et. al* (2006, 2010) have developed an tripartite IO model for China, which differentiates China's domestic production into three types: production of DOEs to meet domestic demand (hereafter "domestic production"), production for processing exports (hereafter "processing exports"), the combination of production for non-processing exports and production of FIEs for domestic use (hereafter "non-processing exports and others")[3] (table 1). To distinguish from the ordinary national IO table, we name this IO table as the tripartite IO table hereafter. Pei et al. (2012), Chen et al. (2012), and Duan et al. (2012) all have applied this table to conduct the trade-related analysis on China.

One important assumption in IO model is that a certain industry is a branch of homogenous product group with similar production technology. However, as we mentioned in the abstract, production

[2] For example, Koopman et al. (2008, 2012) showed that if the processing trade was included in the domestic production, proportion of domestic content in China's exports was 73.7% in 2006. However, if it was not included, this figure was only 50.7%. Pei et al. (2012) also observed that the contribution of the change in exports to China's value-added changes from 2002 to 2007 was 32% higher when the ordinary IO tables are used than when the tables capturing processing trade are used.

[3] Yang et al. (2009) introduced the distinction of production types and the inter-linkages among symbols in detail.

technology of FIEs and DOEs are remarkably different. The fact means that the mixture of production of FIEs and DOEs in IO model may come up with biased estimates or misleading conclusions. Therefore, a wise way to reflect the true picture of China's economy is to separate the production of FIEs from that of DOEs. It is also useful to shed light on the interdependence between FIEs and DOEs, and their separate contribution to GDP growth.

Accordingly, we will differentiate the production of FIEs from that of DOEs based on the tripartite IO model, to construct a six-portion IO model, which differentiates not only the trade pattern but also the ownership of enterprises. The framework of the six-portion IO model is outlined in table 2. In this IO model, China's production is divided into six parts: production of DOEs for domestic demand (hereafter "domestic products of DOEs"); production of DOEs for processing exports (hereafter "processing exports of DOEs");production of DOEs for non-processing exports (hereafter "non-processing exports of DOEs");production of FIEs for domestic demand (hereafter "domestic products of FIEs"); production of FIEs for processing exports (hereafter "processing exports of FIEs");production of FIEs for non-processing exports (hereafter "non-processing exports of FIEs").

**Table 1 China's tripartite input-output framework**

| | Intermediate use | | | Final use | | *TOT* |
|---|---|---|---|---|---|---|
| | *D* | *P* | *N* | *DFD* | *EXP* | |
| *D* | $\mathbf{Z}^{DD}$ | $\mathbf{Z}^{DP}$ | $\mathbf{Z}^{DN}$ | $\mathbf{f}^{D}$ | **0** | $\mathbf{X}^{D}$ |
| *P* | **0** | **0** | **0** | **0** | $\mathbf{e}^{P}$ | $\mathbf{X}^{P}$ |
| *N* | $\mathbf{Z}^{ND}$ | $\mathbf{Z}^{NP}$ | $\mathbf{Z}^{NN}$ | $\mathbf{f}^{N}$ | $\mathbf{e}^{N}$ | $\mathbf{X}^{N}$ |
| *IMP* | $\mathbf{Z}^{MD}$ | $\mathbf{Z}^{MP}$ | $\mathbf{Z}^{MN}$ | $\mathbf{f}^{M}$ | **0** | $\mathbf{X}^{M}$ |
| *VA* | $\mathbf{v}^{D\prime}$ | $\mathbf{v}^{P\prime}$ | $\mathbf{v}^{N\prime}$ | | | |
| *TOT* | $\mathbf{x}^{D\prime}$ | $\mathbf{x}^{P\prime}$ | $\mathbf{x}^{N\prime}$ | | | |

Notes: *D*=domestic products; *P*=processing exports; *N*= non-processing exports and others; *DFD*=domestic final demand; *EXP*=exports; *TOT*=gross industry outputs (and total import in the column TOT); *IMP*=imports; and *VA*=value added. The IO table is expressed in monetary units.

**Table 2 China's six-portion input-output framework**

| | | *Intermediate use* | | | | | | Final use | | *TOT* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *DOEs* | | | *FIEs* | | | *DFD* | *EXP* | |
| | | $D_1$ | $P_1$ | $N_1$ | $D_2$ | $P_2$ | $N_2$ | | | |
| *DOEs* | $D_1$ | $\mathbf{Z}^{D_1D_1}$ | $\mathbf{Z}^{D_1P_1}$ | $\mathbf{Z}^{D_1N_1}$ | $\mathbf{Z}^{D_1D_2}$ | $\mathbf{Z}^{D_1P_2}$ | $\mathbf{Z}^{D_1N_2}$ | $\mathbf{f}^{D_1}$ | **0** | $\mathbf{x}^{D_1}$ |
| | $P_1$ | **0** | **0** | **0** | **0** | **0** | **0** | 0 | $\mathbf{e}^{P_1}$ | $\mathbf{x}^{P_1}$ |
| | $N_1$ | **0** | **0** | **0** | **0** | **0** | **0** | 0 | $\mathbf{e}^{N_1}$ | $\mathbf{x}^{N_1}$ |
| *FIEs* | $D_2$ | $\mathbf{Z}^{D_2D_1}$ | $\mathbf{Z}^{D_2P_1}$ | $\mathbf{Z}^{D_2N_1}$ | $\mathbf{Z}^{D_2D_2}$ | $\mathbf{Z}^{D_2P_2}$ | $\mathbf{Z}^{D_2N_2}$ | $\mathbf{f}^{D_2}$ | **0** | $\mathbf{x}^{D_2}$ |
| | $P_2$ | **0** | **0** | **0** | **0** | **0** | **0** | 0 | $\mathbf{e}^{P_2}$ | $\mathbf{x}^{P_2}$ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $N_2$ | $\mathbf{0}$ | $\mathbf{0}$ | $\mathbf{0}$ | $\mathbf{0}$ | $\mathbf{0}$ | $\mathbf{0}$ | 0 | $\mathbf{e}^{N_2}$ | $\mathbf{x}^{N_2}$ |
| *IMP* | $\mathbf{Z}^{MD_1}$ | $\mathbf{Z}^{MP_1}$ | $\mathbf{Z}^{MN_1}$ | $\mathbf{Z}^{MD_2}$ | $\mathbf{Z}^{MP_2}$ | $\mathbf{Z}^{MN_2}$ | $\mathbf{f}^{M}$ | 0 | $\mathbf{x}^{M}$ |
| *VA* | $\mathbf{v}^{D_1\prime}$ | $\mathbf{v}^{P_1\prime}$ | $\mathbf{v}^{N_1\prime}$ | $\mathbf{v}^{D_2\prime}$ | $\mathbf{v}^{P_2\prime}$ | $\mathbf{v}^{N_2\prime}$ | | | |
| *TOT* | $\mathbf{x}^{D_1\prime}$ | $\mathbf{x}^{P_1\prime}$ | $\mathbf{x}^{N_1\prime}$ | $\mathbf{x}^{D_2\prime}$ | $\mathbf{x}^{P_2\prime}$ | $\mathbf{x}^{N_2\prime}$ | | | |

Notes: *DOEs*=Production of domestic-owned enterprises. *FIEs*=Production of foreign invested enterprises. $D_1$=Production of domestic enterprises to satisfy domestic demand; $D_2$=Production of foreign invested enterprises to satisfy domestic demand; $P_1$= Processing exports of domestic enterprises; $P_2$=Processing exports of foreign invested enterprises; $N_1$= Non-processing exports of Domestic enterprises; $N_2$= Non-processing exports of Foreign invested enterprises; *DFD*=domestic final demand; *EXP*=exports; *TOT*=gross industry outputs (and total import in the column TOT); *IMP*=imports; and *VA*=value added. The IO table is expressed in monetary units.

In table 2, the production of each industry is divided into six types. Correspondingly, the number of 'industries' in it will also be sixfold, compared with those in ordinary IO model. For clarity, we use superscript $D_1$ , $P_1$, and $N_1$ to denote the variables of domestic production of DOEs, processing exports of DOEs, and non-processing exports of DOEs respectively, while using superscript $D_2$ , $P_2$ and $N_2$ to denote the variables of domestic production of FIEs, processing exports of FIEs and non-processing exports of FIEs respectively. Besides, superscript *M* indicates variables of imports. Then several variables can be defined based on the six-portion IO model. Let $\mathbf{x}$ be the output vector, and $\mathbf{f}$ the vector of domestic final demand. Define $\mathbf{e}$ as the exports vector, while $\mathbf{v}$ is the value-added vector. $\mathbf{x}$, $\mathbf{f}$, $\mathbf{e}$ and $\mathbf{v}$ are all with *6n* dimensions including all types of production. More specifically, the matrixes above can be described as: $\mathbf{x}=\begin{pmatrix}\mathbf{x}^{D_1}\\ \mathbf{x}^{P_1}\\ \mathbf{x}^{N_1}\\ \mathbf{x}^{D_2}\\ \mathbf{x}^{P_2}\\ \mathbf{x}^{N_2}\end{pmatrix}$, $\mathbf{f}=\begin{pmatrix}\mathbf{f}^{D_1}\\ \mathbf{0}\\ \mathbf{0}\\ \mathbf{f}^{D_2}\\ \mathbf{0}\\ \mathbf{0}\end{pmatrix}$, and $\mathbf{e}=\begin{pmatrix}\mathbf{0}\\ \mathbf{e}^{P_1}\\ \mathbf{e}^{N_1}\\ \mathbf{0}\\ \mathbf{e}^{P_2}\\ \mathbf{e}^{N_2}\end{pmatrix}$. Define $\mathbf{Z}^{ST}$ to indicate the output from each industry in *S* used as intermediate inputs by each industry in *T,* where $S=D_1, D_2, M$ and $T=D_1, P_1, N_1, D_2, P_2, N_2$. Then the intermediate flow matrix has the form of $\mathbf{Z}=\begin{pmatrix}\mathbf{Z}^{D}\\ \mathbf{Z}^{M}\end{pmatrix}$, where

$$\mathbf{Z}^{D}=\begin{pmatrix}\mathbf{Z}^{D_1D_1} & \mathbf{Z}^{D_1P_1} & \mathbf{Z}^{D_1N_1} & \mathbf{Z}^{D_1D_2} & \mathbf{Z}^{D_1P_2} & \mathbf{Z}^{D_1N_2}\\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0}\\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0}\\ \mathbf{Z}^{D_2D_1} & \mathbf{Z}^{D_2P_1} & \mathbf{Z}^{D_2N_1} & \mathbf{Z}^{D_2D_2} & \mathbf{Z}^{D_2P_2} & \mathbf{Z}^{D_2N_2}\\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0}\\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0}\end{pmatrix}$$

is domestic intermediate delivery matrix and $\mathbf{Z}^{M}$ is import intermediate delivery matrix with $\mathbf{Z}^{M}=\begin{pmatrix}\mathbf{Z}^{MD_1} & \mathbf{Z}^{MP_1} & \mathbf{Z}^{MN_1} & \mathbf{Z}^{MD_2} & \mathbf{Z}^{MP_2} & \mathbf{Z}^{MN_2}\end{pmatrix}$. Note that production of processing exports can only be used as exports. Accordingly, both the intermediate use and domestic final use of processing exports and non-processing exports are 0. Then the six-portion model can be formulated by matrix:

$$\begin{aligned}
&\mathbf{Z}^{D_1D_1}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_1P_1}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_1N_1}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_1D_2}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_1P_2}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_1N_2}\boldsymbol{\mu}_n' + \mathbf{f}^{D_1} = \mathbf{x}^{D_1} \\
&\mathbf{e}^{P_1} = \mathbf{x}^{P_1} \\
&\mathbf{e}^{N_1} = \mathbf{x}^{N_1} \\
&\mathbf{Z}^{D_2D_1}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_2P_1}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_2N_1}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_2D_2}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_2P_2}\boldsymbol{\mu}_n' + \mathbf{Z}^{D_2N_2}\boldsymbol{\mu}_n' + \mathbf{f}^{D_2} = \mathbf{x}^{D_2} \qquad (1) \\
&\mathbf{e}^{P_2} = \mathbf{x}^{P_2} \\
&\mathbf{e}^{N_2} = \mathbf{x}^{N_2} \\
&\mathbf{X}^{MD_1}\boldsymbol{\mu}_n' + \mathbf{X}^{MP_1}\boldsymbol{\mu}_n' + \mathbf{X}^{MN_1}\boldsymbol{\mu}_n' + \mathbf{X}^{MD_2}\boldsymbol{\mu}_n' + \mathbf{X}^{MP_2}\boldsymbol{\mu}_n' + \mathbf{X}^{MN_2}\boldsymbol{\mu}_n' + \mathbf{f}^{M} = \mathbf{x}^{M}
\end{aligned}$$

Where $\boldsymbol{\mu}_n$ is the summation vector with n dimensions. For the domestic production, equation (1) can be simplified as：

$$\mathbf{Z}^{D}\boldsymbol{\mu}_{6n}' + \mathbf{f} + \mathbf{e} = \mathbf{x} \qquad (2)$$

In Leontief production function, it is assumed that the input will be used in fixed (technologically pre-determined) proportions. Accordingly, we can define the following technical coefficients based on equation (2). Define $\mathbf{A}^{ST} = (a_{ij}^{ST})_{n\times n}$, with its element $a_{ij}^{ST} = z_{ij}^{ST} / x_j^{T}$ to be the intermediate input coefficient, describing the output from industry *i* in production *S* used as intermediate input by industry *j* in production *T* as a share of output in the latter industry. Then the direct domestic input coefficient matrix can be expressed as:

$$\mathbf{A}^{D} = \begin{pmatrix} \mathbf{A}^{D_1D_1} & \mathbf{A}^{D_1P_1} & \mathbf{A}^{D_1N_1} & \mathbf{A}^{D_1D_2} & \mathbf{A}^{D_1P_2} & \mathbf{A}^{D_1N_2} \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ \mathbf{A}^{D_2D_1} & \mathbf{A}^{D_2P_1} & \mathbf{A}^{D_2N_1} & \mathbf{A}^{D_2D_2} & \mathbf{A}^{D_2P_2} & \mathbf{A}^{D_2N_2} \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

, while the direct import input coefficient matrix is read as: $\mathbf{A}^{M} = \begin{pmatrix} \mathbf{A}^{MD_1} & \mathbf{A}^{MP_1} & \mathbf{A}^{MN_1} & \mathbf{A}^{MD_2} & \mathbf{A}^{MP_2} & \mathbf{A}^{MN_2} \end{pmatrix}$. The famous Leontief inverse in the six-portion IO model is given by ( $\mathbf{A}^{D}$ is invertible, the proof for which is shown in Appendix A):

$$\mathrm{B} = (\mathbf{I} - \mathbf{A}^{D})^{-1} = \begin{pmatrix} \mathbf{B}^{D_1D_1} & \mathbf{B}^{D_1P_1} & \mathbf{B}^{D_1N_1} & \mathbf{B}^{D_1D_2} & \mathbf{B}^{D_1P_2} & \mathbf{B}^{D_1N_2} \\ 0 & \mathbf{I} & 0 & 0 & 0 & 0 \\ 0 & 0 & \mathbf{I} & 0 & 0 & 0 \\ \mathbf{B}^{D_2D_1} & \mathbf{B}^{D_2P_1} & \mathbf{B}^{D_2N_1} & \mathbf{B}^{D_2D_2} & \mathbf{B}^{D_2P_2} & \mathbf{B}^{D_2N_2} \\ 0 & 0 & 0 & 0 & \mathbf{I} & 0 \\ 0 & 0 & 0 & 0 & 0 & \mathbf{I} \end{pmatrix}$$

Further we define the value-added coefficient vector as $\mathbf{a}_v = \begin{pmatrix} \mathbf{a}_v^{D_1} & \mathbf{a}_v^{P_1} & \mathbf{a}_v^{N_1} & \mathbf{a}_v^{D_2} & \mathbf{a}_v^{P_2} & \mathbf{a}_v^{N_2} \end{pmatrix}$, where

$\mathbf{a}_v^S = (\mathbf{a}_{vj}^S)_{1\times n}$ with element $\mathbf{a}_{vj}^S$ defined as $a_{vj}^S = a_{vj}^S / x_j^S$, describing the value-added per unit output of industry $j$ in production S. By using the coefficients, equation (2) can be further rewritten as:

$$\mathbf{A}^D\mathbf{x} + \mathbf{f} + \mathbf{e} = \mathbf{x} \quad (3)$$

$$\mathbf{x} = \mathbf{B}(\mathbf{f} + \mathbf{e}) \quad (4)$$

By input-output technique, value-added embodied in any final demand can be calculated by post-multiplying value-added coefficients by the gross output needed for production of this final demand. Due to the complicated consumption relations among each kind of products, the production of one product needs various kinds of input from other industries, which further stimulates the production of other products. So based on equation (4), firstly, we can get the output of each industry generated by each types of final demand:

$$\mathbf{tx}^{D_1} = \mathbf{B}^{D_1D_1}\mathbf{f}^{D_1} + \mathbf{B}^{D_2D_1}\mathbf{f}^{D_1} \quad (5.1)$$

$$\mathbf{tx}^{P_1} = \mathbf{B}^{D_1P_1}\mathbf{e}^{P_1} + \mathbf{e}^{P_1} + \mathbf{B}^{D_2P_1}\mathbf{e}^{P_1} \quad (5.2)$$

$$\mathbf{tx}^{N_1} = \mathbf{B}^{D_1N_1}\mathbf{e}^{N_1} + \mathbf{e}^{N_1} + \mathbf{B}^{D_2N_1}\mathbf{e}^{N_1} \quad (5.3)$$

$$\mathbf{tx}^{D_2} = \mathbf{B}^{D_1D_2}\mathbf{f}^{D_2} + \mathbf{B}^{D_2D_2}\mathbf{f}^{D_2} \quad (5.4)$$

$$\mathbf{tx}^{P_2} = \mathbf{B}^{D_1P_2}\mathbf{e}^{P_2} + \mathbf{e}^{P_2} + \mathbf{B}^{D_2P_2}\mathbf{e}^{P_2} \quad (5.5)$$

$$\mathbf{tx}^{N_2} = \mathbf{B}^{D_1N_2}\mathbf{e}^{N_2} + \mathbf{e}^{N_2} + \mathbf{B}^{D_2N_2}\mathbf{e}^{N_2} \quad (5.6)$$

Value-added of each industry generated by each types of final demand can be further obtained:

$$\mathbf{tv}^{D_1} = \hat{\mathbf{a}}_v^{D_1}\mathbf{B}^{D_1D_1}\mathbf{f}^{D_1} + \mathbf{a}_v^{D_2}\mathbf{B}^{D_2D_1}\mathbf{f}^{D_1} \quad (6.1)$$

$$\mathbf{tv}^{P_1} = \hat{\mathbf{a}}_v^{D_1}\mathbf{B}^{D_1P_1}\mathbf{e}^{P_1} + \mathbf{a}_v^{P_1}\mathbf{e}^{P_1} + \hat{\mathbf{a}}_v^{D_2}\mathbf{B}^{D_2P_1}\mathbf{e}^{P_1} \quad (6.2)$$

$$\mathbf{tv}^{N_1} = \hat{\mathbf{a}}_v^{D_1}\mathbf{B}^{D_1N_1}\mathbf{e}^{N_1} + \mathbf{a}_v^{N_1}\mathbf{e}^{N_1} + \hat{\mathbf{a}}_v^{D_2}\mathbf{B}^{D_2N_1}\mathbf{e}^{N_1} \quad (6.3)$$

$$\mathbf{tv}^{D_2} = \hat{\mathbf{a}}_v^{D_1}\mathbf{B}^{D_1D_2}\mathbf{f}^{D_2} + \mathbf{a}_v^{D_2}\mathbf{B}^{D_2D_2}\mathbf{f}^{D_2} \quad (6.4)$$

$$\mathbf{tv}^{P_2} = \hat{\mathbf{a}}_v^{D_1}\mathbf{B}^{D_1P_2}\mathbf{e}^{P_2} + \mathbf{a}_v^{P_2}\mathbf{e}^{P_2} + \hat{\mathbf{a}}_v^{D_2}\mathbf{B}^{D_2P_2}\mathbf{e}^{P_2} \quad (6.5)$$

$$\mathbf{tv}^{N_2} = \hat{\mathbf{a}}_v^{D_1}\mathbf{B}^{D_1N_2}\mathbf{e}^{N_2} + \mathbf{a}_v^{N_2}\mathbf{e}^{N_2} + \hat{\mathbf{a}}_v^{D_2}\mathbf{B}^{D_2N_2}\mathbf{e}^{N_2} \quad (6.6)$$

Where a hat means the diagonal matrix of a vector. For example, equations (5.1) and (6.1) respectively indicate the output and value*-added created in each industry to satisfy the domestic production of DOEs. Summation of equations (5.1), (5.2), and (5.3) offers the value-added induced by total final products of FIEs, while the summation of equations (5.4), (5.5), and (5.6) yields the value-added induced by total final products of DOEs. To be clearer, equations (7.1) and (7.2) provide the contribution of FIEs and DOEs to China's value-added of each industry.

$$\mathbf{c}^1 = (\mathbf{tv}^{D_1} + \mathbf{tv}^{P_1} + \mathbf{tv}^{N_1})(\hat{\mathbf{tv}})^{-1} \quad (7.1)$$

$$\mathbf{c}^2 = (\mathbf{tv}^{D_1} + \mathbf{tv}^{P_1} + \mathbf{tv}^{N_1})(\hat{\mathbf{tv}})^{-1} \quad (7.2)$$

where $\mathbf{tv} = (\mathbf{tv}^{D_1} + \mathbf{tv}^{P_1} + \mathbf{tv}^{N_1} + \mathbf{tv}^{D_1} + \mathbf{tv}^{P_1} + \mathbf{tv}^{N_1})$ gives the total value-added of each industry. When it comes to the national level, the corresponding results can be obtained in similar pattern. This indicates that this framework can not only be used to analyze the contribution of FIEs and DOEs to China's aggregate value-added, but also shed new perspective on the growth origin of value-added of each industry.

Moreover, the production of FIEs and DOEs need inputs from each other and thus promotes mutual development. Equations (5) and (6) depict the dependence between DOEs and FIEs. Taking equation (5.4) as an example, its first item $\mathbf{B}^{D_1D_2}\mathbf{f}^{D_2}$ indicates the output of domestic production by DOEs' generated by FIEs' domestic final demand. Reorganizing equation (5) yields:

$$\mathbf{tx}^{11} = \mathbf{B}^{D_1D_1}\mathbf{f}^{D_1} + \mathbf{B}^{D_1P_1}\mathbf{e}^{P_1} + \mathbf{e}^{P_1} + \mathbf{B}^{D_1N_1}\mathbf{e}^{N_1} + \mathbf{e}^{N_1} \tag{8.1}$$

$$\mathbf{tx}^{12} = \mathbf{B}^{D_1D_2}\mathbf{f}^{D_2} + \mathbf{B}^{D_1P_2}\mathbf{e}^{P_2} + \mathbf{B}^{D_1N_2}\mathbf{e}^{N_2} \tag{8.2}$$

$$\mathbf{tx}^{21} = \mathbf{B}^{D_2D_1}\mathbf{f}^{D_1} + \mathbf{B}^{D_2P_1}\mathbf{e}^{P_1} + \mathbf{B}^{D_2N_1}\mathbf{e}^{N_1} \tag{8.3}$$

$$\mathbf{tx}^{22} = \mathbf{B}^{D_2D_2}\mathbf{f}^{D_2} + \mathbf{e}^{P_2} + \mathbf{B}^{D_2P_2}\mathbf{e}^{P_2} + \mathbf{e}^{N_2} + \mathbf{B}^{D_2N_2}\mathbf{e}^{N_2} \tag{8.4}$$

Where $\mathbf{tx}^{11}$ and $\mathbf{tx}^{22}$ present the output of DOEs and FIEs induced by the final demand of themselves. And $\mathbf{tx}^{12}$ shows the output of DOEs stimulated by final demand of FIEs, while $\mathbf{tx}^{21}$ indicates the output of FIEs stimulated by final demand of DOEs. Further, $\hat{\mathbf{tx}}^{12}(\hat{\mathbf{tx}}^{12} + \hat{\mathbf{tx}}^{11})^{-1}$ shows the dependence of DOEs' output on FIEs, while $\hat{\mathbf{tx}}^{21}(\hat{\mathbf{tx}}^{21} + \hat{\mathbf{tx}}^{22})^{-1}$ illustrates the dependence of FIEs' output on DOEs. Similarly, dependence of DOEs' value-added on FIEs and dependence of FIEs' value-added on DOEs also can be formulated.

Besides the contribution to GDP, the degree of fragmentation of FIEs and DOEs in China also can be measured respectively. It is useful to reflect the different roles of FIEs and DOEs in the global production chain. By now, vertical specialization share (VS share) proposed by Hummels et al. (2001) has been widely adopted to measure the degree of fragmentation and dependence of production on international market. The vertical specialization means the imports embodied in per unit export. In the six-portion IO model, both the VS share of processing exports and non-processing exports for FIEs and DOEs can be obtained in equation.

$$vs^{P_1} = \boldsymbol{\mu}'(\mathbf{A}_M^{D_1}\mathbf{B}^{D_1P_1}\mathbf{e}^{P_1} + \mathbf{A}_M^{P_1}\mathbf{e}^{P_1} + \mathbf{A}_M^{D_2}\mathbf{B}^{D_2P_1}\mathbf{e}^{P_1})(\boldsymbol{\mu}'\mathbf{e}^{P_1})^{-1} \tag{9.1}$$

$$vs^{N_1} = \boldsymbol{\mu}'(\mathbf{A}_M^{D_1}\mathbf{B}^{D_1N_1}\mathbf{e}^{N_1} + \mathbf{A}_M^{N_1}\mathbf{e}^{N_1} + \mathbf{A}_M^{D_2}\mathbf{B}^{D_2N_1}\mathbf{e}^{N_1})(\boldsymbol{\mu}'\mathbf{e}^{N_1})^{-1} \tag{9.2}$$

$$vs^{P_2} = \boldsymbol{\mu}'(\mathbf{A}_M^{D_1}\mathbf{B}^{D_1P_2}\mathbf{e}^{P_2} + \mathbf{A}_M^{P_2}\mathbf{e}^{P_2} + \mathbf{A}_M^{D_2}\mathbf{B}^{D_2P_2}\mathbf{e}^{P_2})(\boldsymbol{\mu}'\mathbf{e}^{P_2})^{-1} \tag{9.3}$$

$$vs^{N_2} = \boldsymbol{\mu}'(\mathbf{A}_M^{D_1}\mathbf{B}^{D_1N_2}\mathbf{e}^{N_2} + \mathbf{A}_M^{N_2}\mathbf{e}^{N_2} + \mathbf{A}_M^{D_2}\mathbf{B}^{D_2N_2}\mathbf{e}^{N_2})(\boldsymbol{\mu}'\mathbf{e}^{N_2})^{-1} \tag{9.4}$$

**3. Data Processing**

Our starting point is the tripartite IO table of 2007 for China, which was jointly constructed by our CAS team and National Bureau of Statistics of China (Chen *et al*, 2012). The six-portion IO table of 2007 is compiled based on the tripartite IO table of 2007. The compilation details of the tripartite IO table has been explicitly described in Chen *et al*.(2012). It is obvious that all the variables of each industry in the tripartite table, including output, value added, intermediate input, and final use, should be split into two parts: one for FIEs and one for DOEs. Firstly, by definition, total domestic production of DOEs and FIEs can be obtained from the tripartite IO table directly. Secondly, for exports, both published and unpublished data have been employed, including data from China's General Administration of Customs (CGAC), National Bureau of Statistics (NBS), and State Administration of Foreign Exchange (SAFE), among others. Statistics from CGAC are disaggregated in great detail, not only by commodity, but also by customs regime (i.e. processing exports/imports vs. non-processing exports/imports), by types of enterprises (FIEs, DOEs), and by locality. By using concordance table [4] between HS-8 digit commodities and input-output classification, all these trade data are regrouped into the industry classification used for IO tables. Processing exports and non-processing exports can be divided into output of FIEs and output of DOEs. Meanwhile, processing imports and non-processing imports also can be split into imports of FIEs and imports of DOEs. With trade data of FIEs and DOEs, import matrix for the six-portion IO model can be obtained by employing RAS procedure on the import matrix of the tripartite IO table. Thirdly, the NBS has conducted special input-output surveys when preparing the 2007 IO tables, surveys on enterprise manufacturing cost and materials-purchasing sources, for instance. Based on these unpublished data, the tripartite IO table, and statistics for FIEs and DOEs from *China's Industry Statistical Yearbook* (NBS, 2008), we can further estimate the value added, import matrix, and domestic intermediate of DOEs and FIEs separately by using modified RAS procedure.

## 4. Empirical Analysis

### 4.1 Contribution of FIEs and DOEs to China's economy

The first fifth rows in table 3 show some basic accounting indicators for FIEs and DOEs, and also for their different production types, that is, domestic production, processing exports, and non-processing exports. The second row shows the output share (share of output of a product in total output), the third row describes the final use share (value of a product used for final use as a proportion in its total output). Results in table 3 indicate that though FIEs have played an important role in China's economy, DOEs still dominate. In 2007, 80.2% of total output is produced by DOEs, while 74.4% of the final demand is also provided by DOEs.

**Table 3 Contribution of FIEs and DOEs to value-added in 2007 (%)**

| | $D_1$ | $P_1$ | $N_1$ | $D_2$ | $P_2$ | $N_2$ | Total exports of DOEs | Total exports of FIEs | Average of DOEs | Average of FIEs |
|---|---|---|---|---|---|---|---|---|---|---|
| Output share | 75.1 | 0.9 | 4.2 | 12.5 | 4.8 | 2.5 | 5.1 | 7.3 | 80.2 | 19.8 |
| Final demand share | 61.8 | 2.2 | 10.5 | 7.5 | 11.8 | 6.2 | 12.7 | 18.0 | 74.4 | 25.6 |

[4] This concordance table was provided by NBS.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Value-added ratio | 34.7 | 20.0 | 29.4 | 27 | 16.9 | 24.0 | 27.7 | 19.4 | 34.2 | 24.2 |
| Import input coefficient | 3.1 | 57.5 | 11.8 | 14.6 | 58.7 | 12.2 | 19.8 | 42.7 | 4.1 | 24.9 |
| Total Value-added share | 89.4 | 38.6 | 79 | 78.7 | 36.3 | 76.9 | 71.9 | 50.2 | 86.5 | 58.6 |
| VS share | 10.6 | 61.4 | 21 | 21.3 | 63.7 | 23.1 | 28.1 | 49.8 | 13.5 | 41.4 |
| Contribution to GDP | 69.6 | 1.1 | 10.4 | 7.5 | 5.4 | 6.0 | 11.5 | 11.4 | 81.1 | 18.9 |

Note: $D_1$=Production of domestic enterprises to satisfy domestic demand; $D_2$=Production of foreign invested enterprises to satisfy domestic demand; $P_1$= Processing exports of domestic enterprises; $P_2$=Processing exports of foreign invested enterprises; $N_1$= Non-processing exports of Domestic enterprises; $N_2$= Non-processing exports of Foreign invested enterprises; Strictly speaking, the figures in fifth row for $D_1$ and $D_2$ is not real VS share, but is the value of imported products embodied in per unit of domestic final demand, because the final demand of $D_1$ and $D_2$ is not exports.

Besides, the figures also indicate the notable differences between FIEs and DOEs. Firstly, most of the products of DOEs are to satisfy domestic demand, while products of FIEs are mainly used for exports, especially for processing exports. Secondly, the production technology between DOEs and FIEs is also very different. The fourth and fifth rows in table 3 offer different production technology of FIEs and DOEs. It is observed that no matter the products are used for exports or domestic production, value-added ratio of DOEs is higher than that of FIEs, while the import input coefficient is lower than that of FIEs. It confirms that the ownership will indeed influence the input structure of production. FIEs tend to use more materials imported from foreign areas, while DOEs prefer to consuming the goods and services produced at home. However, on average, the difference of import input coefficients between DOEs and FIEs (in the last two columns) is much greater than what the first seven columns imply. This is due to the different composition of production types in DOEs and FIEs. Exports, especially processing exports, which has high import dependence, has accounted for a really high share in FIEs' production.

Figures in the sixth row of table 3 give the value-added embodied in per unit of each type of final demand. On average, per unit of final demand of DOEs can induce 0.865 unit of value-added in total, about 47.6% higher than that of FIEs. For the six types of final demand, it turns out that per unit of domestic final demand of DOEs can generate the most value-added, followed by non-processing exports of DOEs. Then per unit of domestic final demand of FIEs can generate the third largest value-added, while per unit of processing exports of DOEs and FIEs induce the least value-added. For the whole economy, about 81.1% of China's value-added is induced by final products of DOEs, while FIEs are only responsible for 18.9% of total value-added. It indicates that DOEs are the major driving force for China's economic growth. Observations also show that about 70% of China's value-added is induced by DOEs' domestic production, while the exports of DOEs only have small effect on China's value-added. Contrary to DOEs, value-added induced by exports of FIEs accounted for 60% of total value-added induced by FIEs. The large export share in FIEs' final demand is an important reason.

As international fragmentation being a hot issue in recent literature, another interesting issue is whether the ownership will impact the degree of fragmentation. It is observed from table 3 that there is no obvious discrepancy in terms of degree of fragmentation between FIEs and DOEs. Value of imports embodied in final demand of DOEs is much lower than that of FIEs. The main reason is the different composition of their final demand, i.e., processing exports account for a much higher share in final demand of FIEs than in final demand of DOEs. When it comes to exports, it shows the VS share of FIEs' exports is much higher than that of DOEs, which indicates that FIEs became more active in participating in the international division of labor and show a higher degree of fragmentation. This is not surprising when considering the characteristics of FIEs, which have much more connections with foreign market and also need a lot of materials or components from the parent enterprises.

### 4.2 Contribution of FIEs and DOEs to industry-specific value-added

Nowadays, along with China's economic growth, the growing energy and environmental problems are increasingly more serious, therefore economic restructuring became the top priority for the Chinese government. One of the efficient ways to adjust economic structure is to stimulate final demand. Accordingly, it is worth investigating the value-added of each industry embodied in specific 'final demand', since it is more relevant in policy guidance.

Table 4 lists the contribution of each final demand to value-added by industry. From another perspective, it also reflects where the value-added created in each industry has eventually flowed into. Several observations based on table 4 are as follows. Firstly, the contributions of each final demand to value-added vary notably at industry level. But for most industries, the final demand by DOEs, especially their domestic final demand, is the dominant driving force of value-added. At industry level, most of China's production is to supply intermediate inputs to produce DOEs' final products. It proves again that DOEs still play the dominant role in China's economy. For consumer service industries, such as Education (39), Public Management and Social Organization (42) and so on, almost all their value-added has finally gone into the domestic final demand of DOEs. This is not surprising as the main function of the consumer service industries is to offer services to consumers directly. However, domestic final demand of FIEs only has a minor contribution to their value-added, which reflects the small market share of FIEs in these industries. In recent years, China is trying to move the economy away from an export-driven growth mode toward a consumption-led one.

Secondly, it is observed that the development of high-tech industries depends more heavily on FIEs compared with other industries. Especially for Manufacture of telecommunication equipment, computer and other electronic equipment (19), about 75% of its value-added is induced by FIEs' final demand. Besides, for Manufacture of measuring instrument and machinery for cultural activity & office work (20), also about 50.8% of its value-added is ascribed to FIEs. Processing exports of FIEs really has played an important role in value-added of these two industries. However, for recent years, there are several policy adjustments on processing exports, for example in 2006, seven batches of prohibited or restricted category in processing exports have been released, which constrained the further development of processing exports. From 2002 to 2010, the share of processing exports in total exports has declined dramatically from 55.27% to 46.92%.

Thirdly, in service industries, another two industries with distinguished features are Leasing and business services (34), and Research and experimental development (35), both of which mainly provide services for producers, serving for enterprises. Final demand of FIEs contributes more than in other service industries in their value-added, which reflects the different production technologies of FIEs and DOEs, that is, FIEs rely more deeply on the research and consulting services than DOEs. The above result is consistent with the finding of Zhou et al. (2002), who indicate that the technological advantages of FIEs are obvious, compared with technology levels in China.

Finally, contrary to the high contribution of domestic final demand of DOEs to service industries, domestic final demand of DOEs are only responsible for 22% of the value-added of Manufacture of textile (07), non-processing exports of DOEs is the main strength for the development of this industry due to the high export scale of this industry. Besides, some traditional manufacturing industries also have high dependence on non-processing exports, such as Processing of timbers and manufacture of furniture (09), and Smelting and pressing of metals (14).

**Table 4 Contribution of FIEs and DOEs to Industry-specific value-added in 2007 (%)**

| Industry Description | $D_1$ | $P_1$ | $N_1$ | $D_2$ | $P_2$ | $N_2$ | *DOEs* | *FIEs* |
|---|---|---|---|---|---|---|---|---|
| 01.Agriculture, Forestry, Animal Husbandry & Fishery | 75.5 | 0.4 | 8.9 | 8.9 | 1.5 | 4.7 | 84.8 | 15.2 |
| 02 Mining and Washing of Coal | 66.4 | 0.7 | 15.1 | 7.1 | 3.6 | 7.1 | 82.2 | 17.8 |
| 03 Extraction of Petroleum and Natural Gas | 66.0 | 0.8 | 14.7 | 7.1 | 4.0 | 7.3 | 81.6 | 18.4 |
| 04 Mining of Metal Ores | 67.6 | 0.9 | 12.5 | 7.5 | 4.1 | 7.4 | 81.0 | 19.0 |
| 05 Mining and Processing of Nonmetal Ores and Other Ores | 74.7 | 0.6 | 10.2 | 4.1 | 4.0 | 6.4 | 85.5 | 14.5 |
| 06 Manufacture of Foods and Tobacco | 69.3 | 0.7 | 6.4 | 15.9 | 2.0 | 5.8 | 76.4 | 23.6 |
| 07 Manufacture of Textile | 21.7 | 2.6 | 49.1 | 5.6 | 5.3 | 15.8 | 73.3 | 26.7 |
| 08 Manufacture of Wearing apparel, leather, furs, down and related products | 47.6 | 2.7 | 11.4 | 10.6 | 7.6 | 20.0 | 61.7 | 38.3 |
| 09 Processing of Timbers and Manufacture of Furniture | 55.4 | 1.1 | 21.5 | 5.5 | 7.5 | 8.9 | 78.1 | 21.9 |
| 10 Papermaking and products, printing and record medium reproduction | 60.0 | 2.0 | 12.2 | 6.6 | 11.0 | 8.2 | 74.2 | 25.8 |
| 11 Processing of Petroleum, Coking, Processing of Nuclear Fuel | 65.9 | 1.3 | 15.3 | 6.5 | 3.8 | 7.2 | 82.5 | 17.5 |
| 12 Chemical Industry | 56.1 | 2.0 | 15.1 | 8.4 | 7.8 | 10.6 | 73.2 | 26.8 |
| 13 Manufacture of Nonmetallic Mineral Products | 81.2 | 0.4 | 7.2 | 3.1 | 2.9 | 5.3 | 88.8 | 11.2 |
| 14 Smelting and Pressing of Metals | 62.8 | 1.1 | 17.5 | 7.1 | 4.0 | 7.5 | 81.4 | 18.6 |
| 15 Manufacture of Metal Products | 51.9 | 1.3 | 12.8 | 6.5 | 11.6 | 15.9 | 65.9 | 34.1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16 Manufacture of General and Special Equipment | 62.6 | 1.2 | 12.7 | 10.8 | 6.2 | 6.6 | 76.4 | 23.6 |
| 17 Manufacture of Transport Equipment | 54.8 | 4.8 | 5.3 | 21.5 | 2.2 | 11.4 | 64.9 | 35.1 |
| 18 Manufacture of Electrical Machinery and Equipment | 49.5 | 3.3 | 14.0 | 11.0 | 14.6 | 7.7 | 66.7 | 33.3 |
| 19 Manufacture of Telecommunication equipment, computer and other electronic equipment | 20.2 | 2.3 | 2.4 | 13.7 | 49.2 | 12.1 | 25.0 | 75.0 |
| 20 Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work | 26.0 | 5.6 | 17.6 | 3.2 | 42.8 | 4.7 | 49.2 | 50.8 |
| 21 Manufacture of Artwork, Other Manufacture | 58.1 | 2.8 | 10.2 | 8.0 | 5.9 | 15.0 | 71.1 | 28.9 |
| 22 Scrap and Waste | 65.2 | 0.9 | 15.0 | 7.0 | 4.5 | 7.5 | 81.0 | 19.0 |
| 23 Electricity and heating power production and supply | 69.9 | 0.8 | 11.4 | 7.0 | 4.2 | 6.7 | 82.1 | 17.9 |
| 24 Gas Production and Supply | 63.1 | 0.6 | 10.2 | 17.0 | 3.1 | 5.9 | 73.9 | 26.1 |
| 25 Water production and supply | 76.6 | 0.7 | 7.6 | 7.0 | 3.6 | 4.6 | 84.8 | 15.2 |
| 26 Construction | 97.9 | 0.0 | 0.8 | 1.1 | 0.1 | 0.1 | 98.7 | 1.3 |
| 27 Transport and Warehousing | 67.5 | 0.9 | 18.0 | 5.2 | 4.1 | 4.3 | 86.4 | 13.6 |
| 28 Post | 71.4 | 0.7 | 15.1 | 4.9 | 3.9 | 4.0 | 87.2 | 12.8 |
| 29 Information Transmission, Computer Services and Software | 79.6 | 0.5 | 5.3 | 5.3 | 3.7 | 5.6 | 85.4 | 14.6 |
| 30 Wholesale and Retail Trade | 67.0 | 2.1 | 10.6 | 7.3 | 9.3 | 3.6 | 79.7 | 20.3 |
| 31 Hotels and Catering Services | 69.7 | 0.4 | 9.1 | 14.2 | 2.3 | 4.2 | 79.3 | 20.7 |
| 32 Finance and insurance | 70.6 | 0.8 | 9.3 | 8.6 | 5.5 | 5.2 | 80.8 | 19.2 |
| 33 Real Estate | 89.5 | 0.3 | 2.4 | 4.9 | 1.5 | 1.4 | 92.2 | 7.8 |
| 34 Leasing and Business Services | 46.8 | 0.8 | 21.1 | 11.0 | 4.2 | 16.1 | 68.7 | 31.3 |
| 35 Research and Experimental Development | 68.6 | 0.8 | 6.7 | 12.4 | 6.7 | 4.9 | 76.1 | 23.9 |
| 36 Comprehensive Technical Services | 75.6 | 0.6 | 6.9 | 8.8 | 3.4 | 4.6 | 83.2 | 16.8 |
| 37 Management of Water Conservancy, Environment and Public Facilities | 90.1 | 0.2 | 3.8 | 2.6 | 1.1 | 2.2 | 94.1 | 5.9 |
| 38 Households' Services and Other Services | 76.4 | 0.4 | 8.3 | 9.7 | 1.9 | 3.2 | 85.2 | 14.8 |
| 39 Education | 98.1 | 0.0 | 0.8 | 0.5 | 0.2 | 0.3 | 98.9 | 1.1 |
| 40 Health, Social Security and Social Welfare | 96.1 | 0.1 | 1.6 | 1.0 | 0.4 | 0.8 | 97.8 | 2.2 |
| 41 Culture, Sports and Entertainment | 77.9 | 0.9 | 8.2 | 3.9 | 3.4 | 5.6 | 87.0 | 13.0 |
| 42 Public Management and Social Organization | 99.5 | 0.0 | 0.3 | 0.1 | 0.0 | 0.0 | 99.9 | 0.1 |

Note: $D_1$=Production of domestic-owned enterprises to satisfy domestic demand; $D_2$=Production of foreign-invested enterprises to satisfy domestic demand; $P_1$= Processing exports of domestic enterprises; $P_2$=Processing exports of foreign-invested enterprises; $N_1$= Non-processing exports of domestic-owned enterprises; $N_2$= Non-processing exports of foreign-invested enterprises. *DOEs*=Production of domestic enterprises. *FIEs*=Production of foreign-invested enterprises.

### 4.3 Dependence between FIEs and DOEs

After evaluating the different contributions of FIEs and DOEs to China's economy, another interesting question is how the development of FIEs and DOEs depends on each other. The results based on equation

(8) are listed in table 5. Final products of FIEs contributed more to the development of DOEs than the contribution of DOEs' final products to FIEs. Per unit of FIEs' final product can result in 0.97 unit of DOEs' output and 0.25 unit of DOEs' value-added in 2007. Meanwhile, Per unit of DOEs' final product can only induce 0.24 unit of DOEs' output and 0.06 unit of DOEs' value-added. That means production of FIEs depends more heavily on DOEs than the dependence of DOEs' production on FIEs. But when taking the scale of FIEs' and DOEs' final demand into consideration, the cases are different. Table 5 shows, in total, FIEs are responsible for about 13.23% of DOEs' total output and 17.06% of DOEs' total value-added, while DOEs contributed much more to FIEs, about 36.24% of FIEs' total output and 40.03% of FIEs' total value-added. It is natural since the final products of DOEs was nearly triple that of FIEs.

Table 5 also reflects where the products of DOEs and FIEs have eventually flowed into. Firstly, most of DOEs' products are used for domestic final demand, while only 17.28% of them are finally exported in 2007. For FIEs, about 50.21% of their products are finally used to meet domestic final demand, while the left 49.79% are exported abroad. Recalling that about 36.87% of FIEs' output is exported directly in 2007, it means about 12.92% (49.79%-36.87%) of FIEs' output is used as the intermediate inputs of exports. Literature tends to emphasize the majority of China's inward FDI is export-oriented FDI and the foreign investors just take China as export platform through direct investment (Zhang, 2005). However, the results in our paper imply that there are still large share of FIEs' products being used to meet domestic final demand.

**Table 5 Interdependence between FIEs and DOEs in 2007**

| | | $D_1$ | $P_1$ | $N_1$ | $D_2$ | $P_2$ | $N_2$ | DOEs | FIEs |
|---|---|---|---|---|---|---|---|---|---|
| Unit effect | Output of DOEs | 2.36 | 1.50 | 1.35 | 1.30 | 0.51 | 1.46 | 2.33 | 0.97 |
| | Output of FIEs | 0.24 | 0.11 | 0.26 | 1.31 | 1.13 | 1.33 | 0.24 | 1.23 |
| | Value-added of DOEs | 0.83 | 0.36 | 0.72 | 0.42 | 0.16 | 0.45 | 0.80 | 0.25 |
| | Value-added of FIEs | 0.06 | 0.03 | 0.07 | 0.37 | 0.20 | 0.32 | 0.06 | 0.28 |
| Total effect | Output of DOEs (%) | 77.52 | 1.75 | 7.50 | 5.20 | 3.21 | 4.82 | 86.77 | 13.23 |
| | Output of FIEs (%) | 30.24 | 0.49 | 5.50 | 19.97 | 27.09 | 16.70 | 36.24 | 63.76 |
| | Value-added of DOEs (%) | 75.96 | 1.17 | 11.20 | 4.70 | 2.85 | 4.12 | 88.33 | 11.67 |
| | Value-added of FIEs (%) | 33.55 | 0.52 | 5.96 | 23.18 | 20.01 | 16.78 | 40.03 | 59.97 |

## 5 Contribution of EU FDI to China's Economy

The framework constructed in this paper can not only capture the contribution of total inward FDI, but also be used to evaluate the contribution of inward FDI by origin to China's economic growth. We will make a rough estimate by taking the FDI to China from EU as an example in this section.

EU is one of the important FDI sources for China. According to MOFCOM (2007), FDI inflow from EU accounted for 11% of China's total inward FDI flow in 2006. Though in recent years, it is observed that this share has declined obviously, to 4.53% in 2011 (NBS, 2012), capital stock originated from EU is believed to contribute significantly to China's economic growth. It is worth evaluating the role of inflow FDI from EU. . For this purpose, we need the industry-wise data on output, value added, final demand, and capital composition of EU-invested enterprises located in China, however, there is little such kinds of data. In this paper, we will estimate the contribution of EU FDI to China's economy from another perspective. We will estimate the contribution of total FDI stock to China's GDP. Then, assume that FDI sourced from each country/region is with no difference in every certain industry. Thus, the contribution of inflow FDI from EU can be evaluated according to the proportion of EU-owned FDI stock in China's total FDI stock. This process includes the following two steps.

1) Estimate the contribution of total FDI stock to China's GDP. Recall that we already have obtained the contribution of total FIEs to China's economy in section 4. However, the establishment and operation of FIEs not only depends on the FDI stock, but also requires domestic-owned capital. For example, Duan et al. (2012) introduced that domestic-owned capital accounted for 24% in total capital of FIEs on average for industry in 2007. From Duan et al. (2012), we further obtain the proportion of foreign-owned capital stock, that is, FDI stock, in total capital of FIEs for each industry. From section 4.2, we can measure the value-added induced by industry-wise final demand of FIEs, which further yields the value-added induced by China's total FDI stock, by multiplying the industry-wise share of FDI stock in China's total capital stock of FIEs.

2) Estimate the proportion of EU FDI stock in China's total FDI stock. To do this, we employ the FDI data from NBS, MOFCOM, and Eurostat (Statistics Database of European Commission)[5]. First, China's total FDI stock is calculated by accumulating annual industry-wise inward FDI flow from annual China Statistical Yearbook. Second, Eurostat has offered us China's industry-wise inward FDI stock invested by EU (i.e., EU FDI stock in China), in which the industries are classified by NACE 1.1. Through concordance between industries in NACE 1.1 and China's IO table, the EU FDI stock in China is regrouped into the industry classification in the six-portion IO table. Third, for the same variable, the statistics from different data sources are usually with discrepancy. For example, total value of China's inward FDI published by NBS and Eurostat are inconsistent. To keep consistent between the two dataset, we use the EU FDI stock data at aggregate level from NBS as the constraint and that by industry extracted from Eurostat as the shares, to estimate the industry-wise EU FDI stock in China. Further the industry-wise proportion of EU FDI stock in China's total FDI stock is also obtained. Finally, we can estimate the contribution of EU FDI stock to China's GDP, by multiplying the industry-wise share of EU FDI stock in China's total FDI stock by the contribution of total FDI stock to China's GDP. The results are listed in

[5] We are grateful to Antonella Puglia and her colleagues from European Commission for their help in extracting the data.

table 6.

**Table 6 Value-added induced by EU FDI**

| Industry Description | Value-added (million RMB) | Value-added Share (%) | Contribution Rate (%) |
|---|---|---|---|
| 01.Agriculture, Forestry, Animal Husbandry & Fishery | 12519 | 4.89 | 0.44 |
| 02 Mining and Washing of Coal | 3878 | 1.52 | 0.88 |
| 03 Extraction of Petroleum and Natural Gas | 5922 | 2.31 | 1.04 |
| 04 Mining of Metal Ores | 2506 | 0.98 | 1.16 |
| 05 Mining and Processing of Nonmetal Ores and Other Ores | 1915 | 0.75 | 1.27 |
| 06 Manufacture of Foods and Tobacco | 8115 | 3.17 | 0.80 |
| 07 Manufacture of Textile | 1612 | 0.63 | 0.33 |
| 08 Manufacture of Wearing apparel, leather, furs, down and related products | 1698 | 0.66 | 0.42 |
| 09 Processing of Timbers and Manufacture of Furniture | 2162 | 0.84 | 0.83 |
| 10 Papermaking and products, printing and record medium reproduction | 3731 | 1.46 | 1.05 |
| 11 Processing of Petroleum, Coking, Processing of Nuclear Fuel | 3630 | 1.42 | 0.97 |
| 12 Chemical Industry | 17294 | 6.76 | 1.37 |
| 13 Manufacture of Nonmetallic Mineral Products | 1885 | 0.74 | 0.30 |
| 14 Smelting and Pressing of Metals | 12953 | 5.06 | 1.09 |
| 15 Manufacture of Metal Products | 6567 | 2.57 | 1.78 |
| 16 Manufacture of General and Special Equipment | 19735 | 7.71 | 2.16 |
| 17 Manufacture of Transport Equipment | 22115 | 8.64 | 3.44 |
| 18 Manufacture of Electrical Machinery and Equipment | 2732 | 1.07 | 0.59 |
| 19 Manufacture of Telecommunication equipment, computer and other electronic equipment | 19569 | 7.65 | 2.87 |
| 20 Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work | 936 | 0.37 | 0.91 |
| 21 Manufacture of Artwork, Other Manufacturing products | 622 | 0.24 | 0.40 |
| 22 Scrap and Waste | 3519 | 1.38 | 1.00 |
| 23 Electricity and heating power production and supply | 8143 | 3.18 | 0.92 |
| 24 Gas Production and Supply | 194 | 0.08 | 0.88 |
| 25 Water production and supply | 390 | 0.15 | 0.71 |
| 26 Construction | 249 | 0.10 | 0.02 |
| 27 Transport and Warehousing | 10277 | 4.02 | 0.70 |
| 28 Post | 220 | 0.09 | 0.61 |
| 29 Information Transmission, Computer Services and Software | 7666 | 3.00 | 1.27 |
| 30 Wholesale and Retail Trade | 26229 | 10.25 | 1.51 |
| 31 Hotels and Catering Services | 8287 | 3.24 | 1.49 |
| 32 Finance and insurance | 16394 | 6.41 | 1.22 |
| 33 Real Estate | 5446 | 2.13 | 0.44 |
| 34 Leasing and Business Services | 6265 | 2.45 | 1.65 |
| 35 Research and Experimental Development | 1218 | 0.48 | 2.02 |
| 36 Comprehensive Technical Services | 1657 | 0.65 | 0.70 |

| | | | |
|---|---|---|---|
| 37 Management of Water Conservancy, Environment and Public Facilities | 287 | 0.11 | 0.26 |
| 38 Households' Services and Other Services | 5786 | 2.26 | 1.44 |
| 39 Education | 412 | 0.16 | 0.06 |
| 40 Health, Social Security and Social Welfare | 526 | 0.21 | 0.14 |
| 41 Culture, Sports and Entertainment | 582 | 0.23 | 0.38 |
| 42 Public Management and Social Organization | 61 | 0.02 | 0.01 |
| **Aggregate** | 255904 | **100** | **0.96** |

Note: 'value added' column describes the value-added of each industry stimulated by EU FDI. The column of 'value-added share' refers to the share of value-added in each industry generated by EU FDI in total value-added generated by EU FDI. The column of 'contribution rate' depicts the proportion of value-added in each industry generated by EU FDI in total value-added of this industry.

Before analyzing on table 6, we first put our concern on the distribution of EU FDI stock by industry in China (see Appendix B). EU FDI stock accounted for 7.51% in China's total FDI stock by the end of 2007. Manufacturing industries and services are the most attractive industry categories to absorb EU FDI. In 2007, about 46.53% and 46.07% of the EU FDI stock in China is mainly distributed in these two categories respectively. In service industries, Finance and insurance (32), Leasing and business services (34) rank the first two in absorbing EU FDI, about 30% of total EU FDI in China. In manufacturing industries, Chemical industry (12) has the largest share of EU FDI stock, followed by Manufacture of transport equipment (17), Manufacture of general and special equipment (16), and Manufacture of telecommunication equipment, computer and other electronic equipment (19). The EU FDI stock in these four industries constitutes 35% of total EU FDI stock in China.

The last row of table 6 provides total value-added induced by EU FDI stock. It is observed that EU FDI has induced 255.90 billion RMB of China's value-added in 2007, accounting for 0.96% of China's total GDP and 6.47% of the value-added induced by total FDI stock. Besides, another interesting observation is which industry has been benefited most from the investment of EU, as also shown in table 6. More specifically, the second column in table 6 shows the value-added of each industry induced by EU FDI, while the third column describes the contribution of value-added induced by EU FDI among industries, that is, the share of value-added by industry in total value-added generated by EU FDI. The last column gives the contribution rate of EU FDI to value-added of each industry, that is, the proportion of value-added induced by EU FDI in total value-added of each industry, which reflects the dependence of each industry on EU FDI.

There are several other observations in table 6. Firstly, Wholesale and retail trade (30) ranks the first in terms of value-added generated by EU FDI, 10.25% of total value-added induced by EU FDI. Besides, industries such as Manufacture of transport equipment (17), Chemical industry (12), Manufacture of telecommunication equipment, computer and other electronic equipment (19), and Manufacture of general and special Equipment (16) are also the main industries benefited from EU FDI. Secondly, an interesting finding is that althoug just little EU FDI has flowed into China's agriculture, it has brought substantial value-added to this industry. This is because products of agriculture are important materials for other industries. When EU FDI has boosted other industries, it also stimulates the development of agriculture indirectly. This suggests that FDI in one industry can not only promote the development of this industry, but also the development of its downstream industries. Thirdly, the results show that most of the industries have low dependence on EU FDI in terms of value added. This is easy to understand since EU-owned firms only account for a low share in China's economy. However, Manufacture of transport equipment (17) and Manufacture of telecommunication equipment, computer and other electronic equipment (19) depended heavily on EU FDI. In particular, for Manufacture of transport equipment (17), about 3.44% of its value-added is generated by EU FDI. The contribution of EU FDI in different industries also provided important information for China's policy adjustment on EU FDI inflow.

**6. Conclusions**

This paper has contributed to the existed literature both methodologically and empirically. In methodology, the paper constructed a new input-output model, which not only distinguishes processing exports from other types of production, but also differentiates the production technology between enterprises with different ownership. The model reflects the complicated relation between FIEs and DOEs. In empirical analysis, there are several findings in this paper. Firstly, though FIEs play an important role in China's economy, DOEs still dominate and have major contribution to China's economic development. In 2007, about 81.1% of China's GDP is ascribed to DOEs, while only 18.9% is resulted from FIEs. Besides, per unit of DOEs' final product can generate much more China's value-added than that by FIEs. Secondly, the import dependence of FIEs is much higher than that of DOEs, which means FIEs are more active in participating in international division of labor and show a higher degree of fragmentation. Thirdly, at industry level, for most of industries, domestic final demand of DOEs is still the dominant driving force to stimulate their development, while contribution of final demand to value-added varies remarkably across the industries. Most of the value-added generated by service industry is by domestic final demand, while a larger share of value-added by high-tech industries has been ascribed to the exports of FIEs. It is proved that China's high-tech industries have comparatively high dependence on production of FIEs, especially on processing exports of FIEs. Another finding is that the production of FIEs depends more heavily on DOEs, compared with the dependence of DOEs' production on FIEs. Though FIEs is generally believed as export-oriented, the results show that about half of FIEs' products is to meet domestic final demand. Besides, we also estimate the contribution of EU FDI to the Chinese economy. It is estimated that the value-added induced by EU FDI contributes 0.96% to China's GDP in 2007. The results also show that value-added generated by EU FDI in Manufacture of transport equipment (17), and Manufacture of telecommunication equipment, computer and other electronic equipment (19), Manufacture of general and special Equipment (16) contributes a higher ratio, i.e., 3.44%, 2.87% and 2.16% to the value-added of corresponding industries, respectively.

The input-output model we developed in this paper is expected to be applicable to other countries for which with a large flow of inward FDI. Furthermore, we believe that this input-output approach will also be useful in obtaining information on the total rather than direct environmental damages caused by enterprises with different ownership, thus contributing to coordinated economic development and policy implications.

## References


Berthélemy, J.-C., Démurger, S., 2000. Foreign Direct Investment and Economic Growth: Theory and Application to China. *Review of Development Economics*, 4, 140-155.

Chen, X.K., Cheng L. K., Fung K. C. and Lau L. J., 2001, The Estimation of Domestic Value-added and Employment Induced by Exports: An Application to Chinese Exports to the United States, *Working Paper No. 94305*, Department of Economics, Stanford University, Stanford, California. Available at: http://www.stanford.edu/~ljlau/Presentations/Presentations/010618.pdf.

Chen, X.K., Cheng, L.K., Fung, K.C., Lau, L.J., Sung, Y.W., Zhu, K., Yang, C., Pei, J., Duan, Y., 2012. Domestic value added and employment generated by Chinese exports: A quantitative estimation. *China Economic Review*, 23, 850-864.

Cheung, K.-Y., Lin, P., 2004. Spillover effects of FDI on innovation in China: Evidence from the provincial data. *China Economic Review* 15, 25-44

Dean, J.M., Fung, K.C., Wang, Z., 2011. Measuring Vertical Specialization: The Case of China. *Review of International Economics* 19, 609-625.

Dees, S., 1998. Foreign Direct Investment in China: Determinants and Effects. *Economics of Planning* 31, 175-194

Duan, Y., Yang, C., Zhu, K., Chen, X., 2012. Does the Domestic Value-added Induced by China's Exports Really belong to China? *China & World Economy*, 20, 83-102.

Hu, A.G.Z., Jefferson, G.H., 2002. FDI Impact and Spillover: Evidence from China's Electronic and Textile Industries. World Economy, 25, 1063-1076.

Hummels, D., Ishii, J., Yi, K.M., 2001. The Nature and Growth of Vertical Specialization in World Trade. *Journal of International Economics*, 54, 75-96.

Koopman, R., Wang, Z. and Wei, S., 2008. How Much of Chinese Exports is Really Made in

China—Assessing Foreign and Domestic Value-added in Gross Exports, *NBER Working Paper No. 14109*, National Bureau of Economic Research, Cambridge, MA.

Koopman, R., Wang Z. and Wei S., 2012, Estimating Domestic Content in Exports When Processing Trade is Pervasive. *Journal of Development Economics*, 99, 178-189

Lau, Lawrence J., Xikang Chen, Leonard K. Cheng, K. C. Fung, Jiansuo Pei, Yun-Wing Sung,Zhipeng Tang, Yanyan Xiong, Cuihong Yang, and Kunfu Zhu, 2006, Estimates of U.S.-China Trade Balances in Terms of Domestic Value-Added, Working Paper No. 295, Stanford Center for International Development, Stanford University. Available online at: http://siepr.stanford.edu/publicationsprofile/1059

Lawrence J. Lau, Xikang Chen, Cuihong Yang, Leonard K. Cheng, K.C. Fung, Yun-Wing Sung, Kunfu Zhi, Jiansu Pei and Zhipeng Tang, 2010, Input-occupancy-output Models of the Non-competitive Type and their Application – an Examination of the China-US Trade Surplus, *Social Sciences in China*, Vol, XXXI, No.1, pp.35-54 (The Chinese version of this paper was published in *Social Sciences in China* in 2007: No. 5, 91-103).

Leontief, W. 1937. Interrelation of Prices, Output, Savings, and Investment, *The review of Economics and Statistics*19 (3), 109-132.

Mah, J.S., 2010. Foreign Direct Investment Inflows and Economic Growth: The Case of Korea. *Review of Development Economics*, 14, 726-735.

MOFCOM (Ministry of Commerce of China), 2007.China Foreign Investment Report 2007, Economy & Management Publishing House, Beijing, China.

NBS (National Bureau of Statistics of China), 2012, China Statistical Yearbook, Beijing: China Statistics Press.

Pei J., Dietzenbacher E., Oosterhaven J., Yang C., 2011, Accounting for China's import growth: a structural decomposition for 1997 – 2005, *Environment and Planning A*, Vol. 43, No. 12, 2971 – 2991

Whalley, J., Xin, X., 2010. China's FDI and non-FDI Economies and the Sustainability of Future High Chinese Growth. *China Economic Review* 21, 123-135.

Yang, C. H., Dietzenbacher, E., Pei, J. S. and Chen, X. K., 2009, The Bias in Measuring Vertical Specialization. 17th International Input-Output Conference, July 13-17 2009, Sao Paulo, Brazil

Yao, S., 2006. On Economic Growth, FDI and Exports in China. *Applied Economics* 38, 339-351

Zhang, Honglin K., 2005. Why does So Much FDI from Hong Kong and Taiwan Go to Mainland China? *China Economic Review* 16, 293-307

Zhang, K.H., Song, S., 2001. Promoting Exports: the Role of Inward FDI in China. *China Economic Review* 11, 385-396.

Zhang, Q., Felmingham, B., 2002. The Role of FDI, Exports and Spillover Effects in the Regional

Development of China. *The Journal of Development Studies*, 38, 157-178.
Zhou, D., Li, S., Tse, D.K., 2002. The Impact of FDI on the Productivity of Domestic Firms: the Case of China. *International Business Review* 11, 465-484.

**Appendix A: Proof of the invertibility of the domestic technology coefficient matrix $\bar{\mathbf{A}}$.**

Proof:
Based on the definition of domestic technology coefficient matrix $\bar{\mathbf{A}}$, any of its elements $a_{ij}$ is with the property of $0 \le a_{ij} < 1$. Assuming $\lambda$ is one of the characteristic roots of $\bar{\mathbf{A}}$, then there is a vector $\mathbf{y}$ with 6n dimensions, which satisfies that $\bar{\mathbf{A}}\mathbf{y} = \lambda\mathbf{y}$. Further we have $\|\bar{\mathbf{A}}\mathbf{x}\| = \|\lambda\mathbf{x}\|$, where $\|\lambda\mathbf{x}\|$ indicates the norm of $\lambda\mathbf{x}$. So it further holds $\|\bar{\mathbf{A}}\mathbf{x}\| = \|\lambda\mathbf{x}\| = |\lambda|\cdot\|\mathbf{x}\| \le \|\bar{\mathbf{A}}\|\cdot\|\mathbf{x}\|$, accordingly, $|\lambda| \le \|\bar{\mathbf{A}}\|$ holds. Then using the matrix 1-norm block, that is, maximum column-sum of a matrix, then we have $|\lambda| \le \|\bar{\mathbf{A}}\|^1 < 1$.

If $\mathbf{I} - \bar{\mathbf{A}}$ is non-invertible, then there must be a non-zero vector $\mathbf{y}_1$, which satisfies $(\mathbf{I} - \bar{\mathbf{A}})\mathbf{y}_1 = 0$, i.e. $\bar{\mathbf{A}}\mathbf{y}_1 = \mathbf{y}_1$. This means 1 is one of the characteristic roots of $\bar{\mathbf{A}}$, which contradicts with the condition of $|\lambda| < 1$. Accordingly, the assumption that $\mathbf{I} - \bar{\mathbf{A}}$ is non-invertible does not hold. Therefore, the statement that $\mathbf{I} - \bar{\mathbf{A}}$ is invertible is proved.

**Appendix B: EU FDI stock in China 2007 (unit: million US$)**

| Industry Description | Corresponding IO code in 2007 | EU FDI stock |
|---|---|---|
| Agriculture, Forestry, Animal Husbandry & Fishery | 01 | 0 |
| Mining and Quarrying | 02,03,04,05 | 3530 |
| Manufacture of food products and tobacco processing | 06 | 1479 |
| Textile goods and Clothes | 07,08 | 377 |
| Wood & paper | 09,10 | 984 |
| Petroleum processing, coking and nuclear fuel processing | 11 | 690 |
| Chemical industry | 12 | 5772 |
| Manufacture of Nonmetallic Mineral Products | 13 | 0 |
| Metal products | 14, 15 | 2760 |
| Manufacture of General and Special Equipment | 16 | 4771 |
| Manufacture of Transport Equipment | 17 | 5833 |
| Manufacture of Electrical Machinery and Equipment | 18 | 0 |
| Manufacture of Telecommunication equipment, computer | 19 | 3163 |
| Manufacture of Measuring Instrument and Machinery for | 20 | 141 |
| Other manufacturing products | 21, 22 | 0 |
| Electricity, gas, water production and supply | 23, 24, 25 | 530 |
| Construction | 26 | 67 |
| Transport and Warehousing | 27 | 2044 |

| | | |
|---|---|---|
| Post | 28 | 19 |
| Information Transmission, Computer Services and Software | 29 | 464 |
| Wholesale and Retail Trade | 30 | 2406 |
| Hotels and Catering Services | 31 | 22 |
| Finance and insurance | 32 | 11420 |
| Real Estate | 33 | 356 |
| Leasing and Business Services | 34 | 8195 |
| Research and Experimental Development | 35 | 761 |
| Comprehensive Technical Services | 36 | 0 |
| Management of Water Conservancy, Environment and | 37 | 0 |
| Households' Services and Other Services | 38 | 26 |
| Education | 39 | 0 |
| Health, Social Security and Social Welfare | 40 | 0 |
| Culture, Sports and Entertainment | 41 | 0 |
| Public Management and Social Organization | 42 | 0 |
| **Aggregate** | | **55810** |