Preliminary draft!

Taxation Reform on Intermediate Imports and its Implications for Structure Adjustment of Chinese Economy: A CGE Model Based Analysis

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Abstract: Since China's reform and opening up, China's tax system has constantly been adjusted and it has played a very important role in China's economic growth and trade development. From the 1980s to the early 21st century, China's processing trade flourished, accounting for half of the country's foreign trade volume. The introduction of processing trade regime has accelerated the development of intermediate trade and increased China's participation in the global value chains (GVCs). However, with the economic development and the change terms of trade, the tax system has become increasingly inconsistent with the economic growth and upgrading of economic structure. Even pressing, China is facing the pressure of structure adjustment and upgrading in global value chain. Therefore, it is important to discuss how to adjust the existing tax system to facilitate China's economic transformation and help China to upgrade its position in GVCs (e.g., increasing high-tech exports and services or capturing a larger share of value chains than before). With the deepening of global division along GVC, the intermediate trade becomes more and more important for upgrading in GVC and it is essential for China to reform the taxation of intermediate trade. This paper will focus on the effect of this reform on China's economy. To simulate the reform of taxation policy, this study will construct a China's computable general equilibrium (CGE) model. After the construction of the model, exercises are performed to offer a flavor of the possible effects of taxation reform on imported intermediates on China's economy structure. We conclude by providing directions for future research using such model.

Keywords: CGE model; heterogeneous technologies; processing trade; China

JEL Codes: C68; F14; H20; F17

1. Introduction

In 2013, China's merchandise trade amounted to $4160 billion, surpassed the US and became the first largest trading nation. However, this by no means reflects the *de facto* trade position of China. The primary reason is that, China has introduced a dual trade regime since its opening-up to the world, i.e. two types of trade coexist within China's statistics. In fact, simply adding the two types of trade to obtain the total trade is problematic.

Processing trade – featured by duty drawbacks -- accounted for roughly half of China's trade volume in recent years. Figure 1 gives historical evolution of China's processing exports as percentage of total exports from 1981 till 2011. When China's foreign export volume was small in 1980s, the share of processing exports was relatively low (less than 40%) but saw increasing significance; then in most of 1990s and till 2007, processing exports accounted for more than half of total exports, accompanied with the surge of export volume.

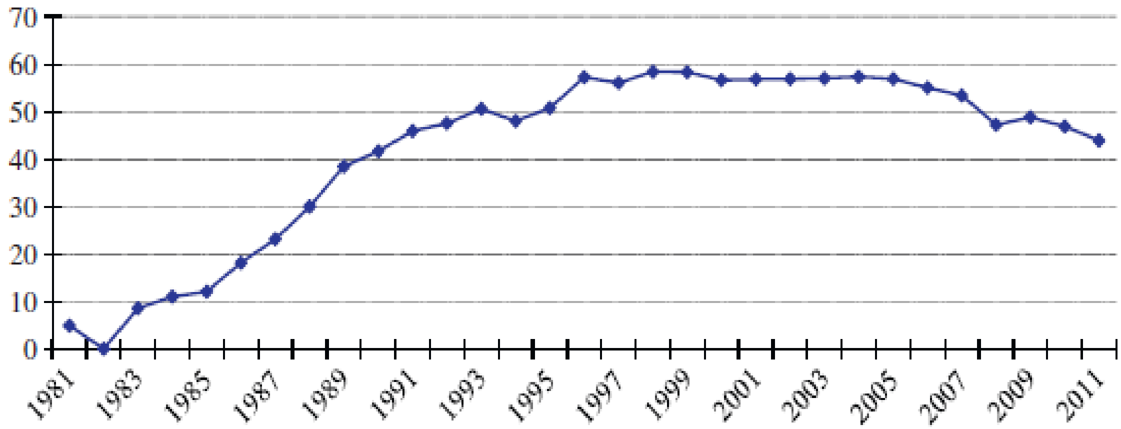

Figure 1 China's share of processing exports in total exports, 1981-2011

Taking into account that processing trade is mainly conducted by foreign-invested enterprises (FIEs) and governed by different customs rule (e.g., processing imports are duty-free, which can only be used to produce processing exports and other means are strictly prohibited), which rely heavily on imported inputs; the double-counting nature of processing trade is evident.[1]

[1] To illustrate this idea, suppose that the FIEs import 100 million dollars of duty-exempt processing imports for the purpose of assembling processing exports, then 100 million dollars of imports are shown in the statistics; after simple assembly or processing treatment, these goods are exported in the form of processing exports, assuming the value would be 110 million dollars, so the Customs put the number 110 million dollars. Thus, in total the trade volume would be reported as 210 million dollars (100 million

Any analysis involving trade volume ignoring the difference between normal trade and processing trade would suffer from such problem. Our first contribution is to clarify this heterogeneity within the context of computable general equilibrium (CGE) modeling.

Duty drawbacks for processing trade bring a wedge for different production technologies and may have strong welfare implications (Panagariya, 1992). In fact, the production technologies of processing trade exhibit sheer difference from the rest of the economy (e.g., processing trade uses relatively more imported inputs than the rest of the economy). Heterogeneous production technologies exist within even finely disaggregated products (say, the HS 6-digit commodities). It is in line with the heterogeneous firms' theory (Melitz, 2003), and empirically confirmed by China's micro data work (Yao et al., 2015).

As simplified version of CGE models, input-output (IO) analysis based on IO tables has seen exciting developments. In particular, via incorporating the features of heterogeneous technologies, recent studies show that, the conventional IO tables need to be refined (Chen et al., 2001; Dean et al., 2011; Chen et al., 2012; Dietzenbacher et al., 2012; Tang et al., 2014, among others). Further, IO literature has demonstrated the importance of capturing processing trade and has shown the consequences of not being able to account for such properties (see Dean et al., 2011; Yang et al., 2015). However, CGE models for China have not paid much attention to the developments in IO techniques, mainly due to the availability of data. Ianchovichina (2004) is among the first attempting to explicitly model the duty drawback issue in CGE modeling (see also Wang, 2003; Ianchovichina and Martin, 2004 for applications).

Building upon latest developments in IO (thanks to the work pioneered by Chen et al., 2001), and the incorporation of theoretical framework for duty drawback (Panagariya, 1992) and CGE modeling efforts due to Koopmand et al. (2013) and Ianchovichina (2004), we have made two refinements. First, we relaxed some of the assumptions made in Ianchovichina (2004), for

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processing imports plus 110 million processing exports). Evidently, such calculation involves serious double-counting (an extreme case for recent discussions about the measurement of trade in value added, or TiVA, see OECD/WTO joint "Made in the World" Initiative). This practice is about to change according to the guidance of BPM6 (Balance of Payments Mannual 6), where ownership would be the gauge for statistics. Concequently, even larger wedge would be driven in China's trade statistics (released by China Customs that follows conventional method) and balance of payments statistics (estimated by State Adminstration of Foreign Exchange that adopts BPM6 recommendation). In fact, the NBS switched to the BPM6 guidelines starting from the compilation of China's 2007 benchmarkt IO table, where processing fee showed up in trade statistics rather than the trade volume.

instance, the complete decouple of productions for exports and for domestic uses; Second, welfare implications are tested under different scenarios in light of China's recent policy debates. More importantly, proportionality assumption is amended via utilizing intensively of micro data, in particular, the IO survey and economic census conducted by National Bureau of Statistics (NBS) and import data provided by China Customs, and the tax data from Ministry of Finance and State Administration of Taxation.

To facilitate our modeling work, the next section gives brief introduction of IO framework exhibiting heterogeneous production technologies. Taking Section 2 as starting point, the CGE modeling incorporating duty drawbacks is demonstrated in Section 3. Following Ianchovinchina (2004), simulation results are presented by "comparing" different models. The last section concludes with discussions for future extensions. More specifically, the paper will first summarize the existing taxation policy on trade; especially compare tax policy for processing trade with normal trade. Secondly, based on micro-level enterprise survey data, custom data and NBS's input-output table, a new China's input-output table in 2010 was compiled, which distinguished different firms (state-owned enterprises, FIEs and other enterprises) and show detail information for the structure of export and import. Then the detail data of national account and taxation will be incorporated to construct a China's social accounting matrix. In this database, detail tax information (especially trade-related tax) will be depicted. Tariffs, other import-related taxes and export rebates will be separated. In the meantime the database will break down the tax data into different firms.

Thirdly, with the compiled input-output table and SAM, the paper will analyze the composition of trade, tax burden and trade cost from the perspective of firm heterogeneity. The paper will compare different firms in terms of production structure, trade structure, tax burden, trade cost, etc. Fourthly, this paper will construct a China's computable general equilibrium (CGE) model. The heterogeneity of firm will be taken into account, and the firms in the model will be divided into two types (export processing enterprises and other enterprises) according to trade regime. Different production function and tax regime will be set for different firms. In addition, the trade of intermediate goods and final goods will be treated differently in the model. The model will be calibrated according to the China's social accounting matrix in 2010 above.

Fifthly, this part will design the scenarios of tax reform. In China, processing trade (mainly intermediate goods) has be entitled to more favorable terms of tax (including tariff and value added tax, i.e. VAT) than other trade regime (mainly normal trade), e.g. there is no tariff for intermediate import under the processing trade regime. Hence, the trade cost of processing trade is much lower than normal trade. As discussed above, this paper will focus on the reform on tax of intermediate trade. Therefore for the tax reform scenario, the model assume the favorable terms of tax for processing trade will be applied to normal trade, i.e. the tax on all intermediate import will be eliminated. Finally, the tax reform scenario will be simulated and compared based on the China's computable general equilibrium model. Comparing the result with reform and without reform, the paper will show the impact of tax reform on the adjustment of industrial structure, as well as other impact on China's economy. Policy implications will be derived after simulation analysis.

2. Input-Output framework distinguishing heterogeneous technologies

This section starts with an introduction to a typical IO table -- the core data that are used in CGE modeling (see Hertel and Tsigas, 1997, among others), implicit assumptions are revealed and possible biases are discussed. Then, we will set out the IO framework that relaxes some of the assumptions stated above, and further incorporates recent development in trade theory (in particular the heterogeneous firms' theory) and data collection. Finally, the basic accounting relations will be presented, which serve as building blocks for the CGE model.

The starting point is a typical IO table, which treats imported goods and domestically produced ones as perfect substitutes. Specifically, imported intermediates are mixed with domestic intermediates. However, empirical evidence suggests that goods from different origin are imperfect substitutes, i.e. the so-called Armington treatment. In order to split-up domestic intermediates and imported counterparts, proportionality assumption is widely used, where equal share of import use applies to each row (i.e., each sector) irrespective of intermediates or final uses. But such treatment suffers from serious biases (as reported in Feenstra and Jensen, 2012; see also Yao et al., 2015). Consequently, we need to adapt the typical IO table to incorporate several properties that are essential in light of empirical evidence.

First of all, given that firms usually do not have the incentive (and sometimes they simply do not possess the information) to distinguish input sources, rather they would report inputs irrespective of origin (whether domestically produced or imported). A typical IO survey does not help in this respect. Second, since its opening-up to the world trade, China has adopted a dual trade regime, where two distinct types of trade coexist. Processing trade features with processing imports imported to China, and after simple assembly re-exported as processing exports. What is involved in such activities is basically China's processing fee.[2] Whereas, normal trade does not have anything special in terms of rules or regulations, i.e. no clear link is found for normal export and normal import. In this sense, one may expect that the production technology (in particular, the share structure of imported goods versus domestically sourced intermediates) for processing trade would differ from that for normal trade.

These issues call for an adaption of conventional IO table. Pioneered by Chen et al. (2001), processing trade in China's IO table was explicitly distinguished; and due to Dean et al. (2011), the UN BEC was combined with HS classification codes as well as the concordance table with IO sectors, proportionality assumption is remedied to some extent. In addition to these refinements, recent studies have been working closely with statistical agencies (e.g., Chen et al., 2001; Lau et al., 2007; Chen et al., 2012; Koopman et al., 2014). In particular, they have established collaboration through various research projects. For example, the key project jointly launched by Ministry of Commerce, National Bureau of Statistics (NBS), China Customs and State Administration of Foreign Exchange. As one may anticipate that the spilt-up of IO table requires not only the knowledge about input output relations but also (and maybe even more crucial) intensive data support. Through the collaboration between research institutes and ministries, both the scientific part and data part of the work are mutually beneficial. In this way, the compilation of China's IO table with heterogeneous production technologies is conducted (details of the table estimation please refer to Tang et al., 2014).

Next, we will give formal introduction of the tripartite IO table. As the name suggests, tripartite IO table has three heterogeneous production technologies: the SOE class, gives the

[2] When measured by the so-called vertical speicialization (VS) share as proposed in Hummels, Ishi and Yi (2001), processing trade has a strikingly higher VS share (see Yang et al., 2015 for more detail; see also Dean et al., 2011). It is also closely related to a recent hot debated concept, namely the global value chain (GVC), or trade in value added (TiVA).

production by state-owned enterprises; the FIE class, represents the production of FIEs (noting that giant share of processing trade is conducted by FIEs); and the OIE class, it provides other production both for foreign and for domestic final use. And the resulting IO table is given by Figure 2.

Figure 2. The structure of China's input-output table distinguishing firm types

	Intermediate use			Final use		
	SOE	*FIE*	*OIE*	*DFD*	*EXP*	*TOT*
SOE	$\mathbf{Z}^{SS}$	$\mathbf{Z}^{SF}$	$\mathbf{Z}^{SO}$	$\mathbf{f}^{S}$	$\mathbf{e}^{S}$	$\mathbf{x}^{S}$
FIE	$\mathbf{Z}^{FS}$	$\mathbf{Z}^{FF}$	$\mathbf{Z}^{FO}$	$\mathbf{f}^{F}$	$\mathbf{e}^{F}$	$\mathbf{x}^{F}$
OIC	$\mathbf{Z}^{OS}$	$\mathbf{Z}^{OF}$	$\mathbf{Z}^{OO}$	$\mathbf{f}^{O}$	$\mathbf{e}^{O}$	$\mathbf{x}^{O}$
IMP	$\mathbf{M}^{S}$	$\mathbf{M}^{F}$	$\mathbf{M}^{O}$	$\mathbf{f}^{M}$	0	$\mathbf{x}^{M}$
VA	$(\mathbf{v}^{S})'$	$(\mathbf{v}^{F})'$	$(\mathbf{v}^{O})'$			
TOT	$(\mathbf{x}^{S})'$	$(\mathbf{x}^{F})'$	$(\mathbf{x}^{O})'$			

Notes: *SOE* = production of state-owned enterprises; *FIE* = production of FIEs; *OIE* = other production; *DFD* = domestic final demands; *EXP* = exports; *TOT* = gross industry outputs (and total imports in the column *TOT*); *IMP* = imports; and *VA* = value added. The input-output table is expressed in monetary units (of 10,000 Yuan).

For illustrative purpose, assuming each typical firm adopting one specific production technology produces one differentiated goods, and the goods can be used either for intermediate or final uses, resulting in a three sector economy. It is worth noting that, according to China's special rule concerning processing trade, processing imports can only be used for the production of processing exports. Assuming further there is no tax in this economy with heterogeneous production technologies albeit rather simplified. Now we are in a position to formulate the accounting relationships between input and output, and market clearing conditions.

From an output perspective for product market, we have

$$\underbrace{Z^{SS}+Z^{SF}+Z^{SO}}_{INTERMEDIATE}+\underbrace{f^{S}+e^{S}}_{FINAL}=x^{S} \qquad \text{for SOE class production technology;}$$

$$\underbrace{Z^{FS}+Z^{FF}+Z^{FO}}_{INTERMEDIATE}+\underbrace{f^{F}+e^{F}}_{FINAL}=x^{F} \qquad \text{for FIE class production technology;}$$

$$\underbrace{Z^{OS}+Z^{OF}+Z^{OO}}_{INTERMEDIATE}+\underbrace{f^{O}+e^{O}}_{FINAL}=x^{O} \qquad \text{for OIE class production technology;}$$

In compact form, and letting all prices in base year be ones, outputs (the quantity model in IO literature) are given by (i.e., market clearance condition)

$$\begin{bmatrix} A^{SS} & A^{SF} & A^{SO} \\ A^{FS} & A^{FF} & A^{FO} \\ A^{OS} & A^{OF} & A^{OO} \end{bmatrix}\begin{bmatrix} x^{S} \\ x^{F} \\ x^{O} \end{bmatrix}+\begin{bmatrix} f^{S}+e^{S} \\ f^{F}+e^{F} \\ f^{O}+e^{O} \end{bmatrix}=\begin{bmatrix} x^{S} \\ x^{F} \\ x^{O} \end{bmatrix}$$

In a similar fashion, from an input perspective, we have

$$\underbrace{\underbrace{Z^{SS}+Z^{FS}+Z^{OS}}_{DOMESTIC}+\underbrace{M^{S}}_{IMPORTED}}_{INTERMEDIATE}+\underbrace{v^{S}}_{FACTORS}=x^{S} \qquad \text{for SOE class production technology;}$$

$$\underbrace{\underbrace{Z^{SF}+Z^{FF}+Z^{OF}}_{DOMESTIC}+\underbrace{M^{F}}_{IMPORTED}}_{INTERMEDIATE}+\underbrace{v^{F}}_{FACTORS}=x^{F} \qquad \text{for FIE class production technology;}$$

$$\underbrace{\underbrace{Z^{SO}+Z^{FO}+Z^{OO}}_{DOMESTIC}+\underbrace{M^{O}}_{IMPORTED}}_{INTERMEDIATE}+\underbrace{v^{O}}_{FACTORS}=x^{O} \qquad \text{for OIE class production technology;}$$

Zero profit for each typical firm requires that total cost equal total revenue, that is the sum of each column (adjusted with proper prices) equals the sum of each row (times proper pirces). As long as their is no tax in the system, it is possible to normalize all prices to 1. In this way, we are essentially computing the share structure for each input. To facilitate our analysis, **A** is defined as the intermediate input coefficient, with its typical element given by $A^{SS} = Z^{SS}(x^S)^{-1}$ and **c** is defined as the value added coefficient, with its typical element expressed as $c^O = v^O(x^O)^{-1}$. Thus, the input structure can be rearranged as,

$$\underbrace{\underbrace{A^{SS} + A^{FS} + A^{OS}}_{DOMESTIC} + \underbrace{A^{MS}}_{IMPORTED}}_{INTERMEDIATE} + \underbrace{c^S}_{FACTORS} = 1 \qquad \text{coefficients form for SOE class;}$$

$$\underbrace{\underbrace{A^{SF} + A^{FF} + A^{OF}}_{DOMESTIC} + \underbrace{A^{MF}}_{IMPORTED}}_{INTERMEDIATE} + \underbrace{c^F}_{FACTORS} = 1 \qquad \text{coefficients form for FIE class;}$$

$$\underbrace{\underbrace{A^{SO} + A^{FO} + A^{OO}}_{DOMESTIC} + \underbrace{A^{MO}}_{IMPORTED}}_{INTERMEDIATE} + \underbrace{c^O}_{FACTORS} = 1 \qquad \text{coefficients form for OIE class.}$$

Introducing the price for each output, the so-called price model is obtained (cost equals revenue in equilibrium), which is a compact form for the input structure with all prices set to unity (i.e., the zero profit condition for each typical firm)

$$\underbrace{\begin{bmatrix} p^S & p^F & p^O \end{bmatrix} \begin{bmatrix} A^{SS} & A^{SF} & A^{SO} \\ A^{FS} & A^{FF} & A^{FO} \\ A^{OS} & A^{OF} & A^{OO} \end{bmatrix}}_{MATERIAL-COST} + \underbrace{\begin{bmatrix} p^{vS}c^S & p^{vF}c^F & p^{vO}c^O \end{bmatrix}}_{FACTOR-COST} = \underbrace{\begin{bmatrix} p^S & p^F & p^O \end{bmatrix}}_{REVENUE}$$

Here, p^{vj} gives prices for primary factors of each production technolgoy (j = S, F, O). It is straightforward to introduce various distortions to the simple economy, for example the output tax and/or input tax. The tax will drive a wedge between the prices faced by producers and received by consumers. This shall be clear in the following section.

For income balance, we know that income side (i.e., the sum of value added) equals the expenditure side (i.e., domestic final uses plus net exports in this simplified example) of gross domestic product (GDP). In formula (all prices are normalized to 1),

$$\underbrace{v^S + v^F + v^O}_{INCOME} = \underbrace{f^S + f^F + f^O}_{CONSUMPTION} + \underbrace{\underbrace{e^S + e^F + e^O}_{EXPORT} - \underbrace{(M^S + M^F + M^O + f^M)}_{IMPORT}}_{NET-EXPORT}$$

Table 1 gives the input structure of 2010 IO table distinguishing firm types. Heterogeneity is evident from Table 1. The left panel gives input structures in absolute values (i.e., **Z**), where sheer size differences are revealed. For example, the OIE class production was roughly three times as much as SOE/FIE class production (75090 billion Yuan vs. 24767 billion Yuan). In terms of input share structure (see right panel of Table 1, corresponding to **A**), the heterogeneity is also pronounced when measured by shares of imported intermediates, which ranged from 0.05 (for OIE class production) to 0.12 (for FIE production).

Since each column in right panel of Table 1 sum to unity (by definition), high imported intermediates share accompanied with relatively low share of domestically produced intermediates and value added. In last row of right panel, we present one more indicator, namely the capital-labor ratio, which serves to give indication about the position of each production technology either capital-intensive or labor-intensive. In general, it seems that OIE production is labor-intensive, whereas FIE production is capital-intensive.

Table 1. Heterogeneous production structures revealed in China's DPN IO table, 2010

	Input structures (2010 billion Yuan)			Input structures (shares)		
	SOE	*FIE*	*OIE*	*SOE*	*FIE*	*OIE*
SOE	5464	3448	8856	0.22	0.14	0.12
FIE	2843	4553	7182	0.11	0.18	0.10
OIE	6845	8302	29169	0.28	0.33	0.39
IMP	1376	3098	3762	0.06	0.12	0.05
VA	8239	6006	26120	0.33	0.24	0.35
*TOT / K-L**	24767	25407	75090	*1.45**	*1.54**	*0.95**

Note: see notes in Fig. 2. And *K-L* gives the capital-labor ratio (last row in right panel), an indication of capital-intensive or labor-intensive nature of specific production class, e.g. 0.95 means the OIE production is labor-intensive.

So far we have established the basic accounting framework of IO model, without tax distortions. Before a thorough analysis of the consequences of tax distortion, we would like to highlight two points. First, as tax can be roughly grouped into two types (output tax or input tax), each will have different welfare impacts (e.g., producers and consumers face different prices), therefore a careful study about the nature of tax is important. Second, due to China's dual trade regime, processing imports (mainly used by FIE production) are duty-free, thus trade liberalization will have different impacts for exports by FIE production and normal exports (mainly conducted by SOE and OIE production, which rely on normal imports that subject to import tariff), where agent-specific input tax should be taken into full account.

Table 2. Export taxes distinguished by firm types (average of manufacture goods), 2010

	Export tax rate (per unit of export)	Export tax rebate rate (per unit of export)
SOE	0.0249	0.14043
FIE	0.0004	0.02766
OIE	0.0022	0.08244

The nice thing about our extended IO table is that, it incorporates detail information of taxes, such as export tax (and tax rebate), import tax, consumption tax and VAT. Table 2 reports export tax and export tax rebate levied on different firms. Considering only manufacture goods, ranging from sector 6 (Manufacture of food; and wine, spirits, tabacco and soft drinks products) to sector 21 (Cultural and office equipment, Craft and other manufacturing products), we observe large heterogeneity. It is found that, SOE production has both relatively high export tax rate (2.5%) and export tax rebate rate (14%).

Further, we calculated the import taxes, consumption taxes, and VAT of intermediate goods for different firm types. On the one hand, directly involved imported intermediates (i.e., sector 6 through sector 21) were used for the estimation (upper panel of Table 3); all imported intermediates were taken into account (lower panel of Table 3).

Table 3. Import tariff, consumption tax and VAT of intermediates by firm types

Coverage of imported intermediates: sector 6 through sector 21			
	Import tariff rate (per unit of imported	Consumption tax rate (per unit of imported	VAT rate (per unit of imported intermediates)

	intermediates)	intermediates)	
SOE	0.03210	0.06308	0.13143
FIE	0.01989	0.03739	0.07262
OIE	0.00962	0.02293	0.04441
Coverage of imported intermediates: sector 1 through sector 42			
	Import tariff rate (per unit of imported intermediates)	Consumption tax rate (per unit of imported intermediates)	VAT rate (per unit of imported intermediates)
SOE	0.01343	0.04542	0.08592
FIE	0.01919	0.04061	0.07546
OIE	0.00668	0.01950	0.03608

It is found that, in general OIE faced lowest tax burden among all firm types. SOE production, which has longer domestic production chain, was observed to have larger tax burden than FIE production. In this sense, it is expected that input liberalization (i.e., elimination of taxes on normal imported intermediates) will have different impact on heterogeneous firms, thus have impact on economic structure.

3. The extended CGE Model

This section develops the extended CGE model, which takes the conventional model (e.g., GTAP model, see Hertel and Tsigas, 1997) as starting point. First, we introduce new ingredients in the extended CGE model contrasting with standard model; this will serve as the benchmark for further discussions. Then, some abstract analytical results will be presented, and by contrasting the new model with conventional models, it is revealed further that the extended CGE fits better to empirical evidence.

3.1 Firms/Production

The heterogeneity of firm will be taken into account, and the firms in the model will be divided into three types (SOE production, FIE production and OIE production enterprises) according to firm heterogeneity. As for each firm, the production, like in most CGE models, relies on the substitution relations across factors of production, intermediate goods, and production taxes (and production subsidies). Production technology is assumed to exhibit constant return to scale. The production structure in this model has a single constant-elasticity-of-substitution (CES) relation between capital and labor, with intermediate goods and production taxes being used in fixed proportion (i.e., Leontief production function) to output.

The advantage of our extended CGE model is that the taxes, including consumption tax and VAT for commodity sales, and taxes levied on intermediate goods are fully accounted for. Specifically, for domestic intermediates, we separate consumption tax and VAT, while for imported intermediates, import tariff, consumption tax and VAT are depicted in the model (see Figure 3 for details).

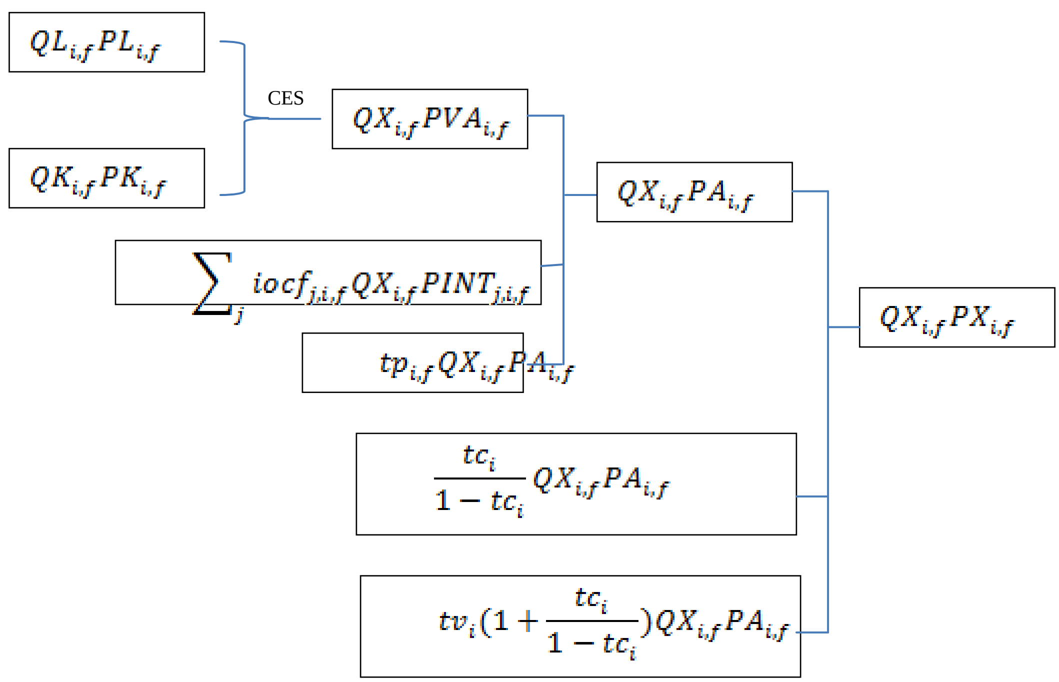


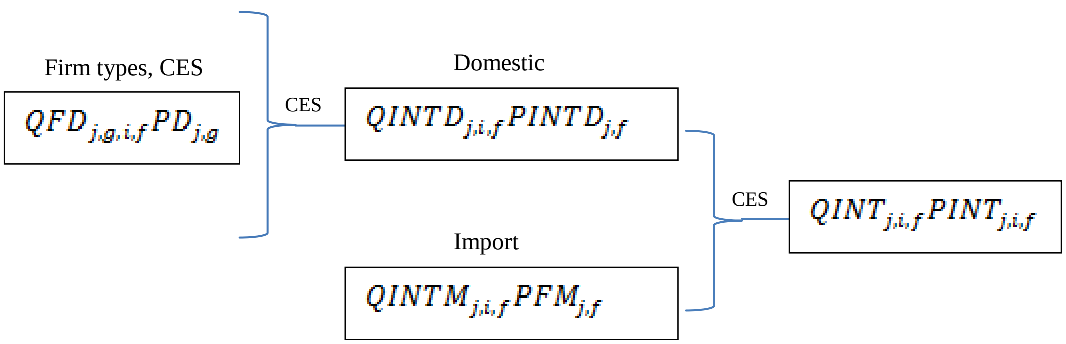
Figure 3. The input and output of industry *i* for production class *f*

It is observvd that the intermediate inputs, i.e. $iocf_{j,i,f}QX_{i,f}PINT_{j,i,f}$ is the composite goods of domestically sourced and imported for enterprise (*i*, *f*). Where, the VAT levied on domestically sourced inputs would be $\sum_j QFD_{j,g,i,f}PA_{j,g}(1+\frac{tc_j}{1-tc_j})tv_j$, whereas that for imported intermediate inputs would be $\sum_j QINTM_{j,i,f}PWM_jEXR(1+tfm_{j,f})(1+\frac{tfmc_{j,f}}{1-tfmc_{j,f}})tfmv_{j,f}$. For all producers, they need to pay VAT and other production tax (including production subsidies). Their VAT payable are calculated as the difference between tax on sectoral output and the deductible VAT arising from the use of taxed intermediate input (including domestic goods and imported goods), given by

$$tp_{i,f}QX_{i,f}PA_{i,f} - \sum_{j} QINTM_{j,i,f}PWM_{j}EXR(1 + tfm_{j,f})\left(1 + \frac{tfmc_{j,f}}{1 - tfmc_{j,f}}\right)tfmv_{j,f}$$

$$- \sum_{j} QFD_{j,g,i,f}PA_{j,g}(1 + \frac{tc_{j}}{1 - tc_{j}})tv_{j}$$

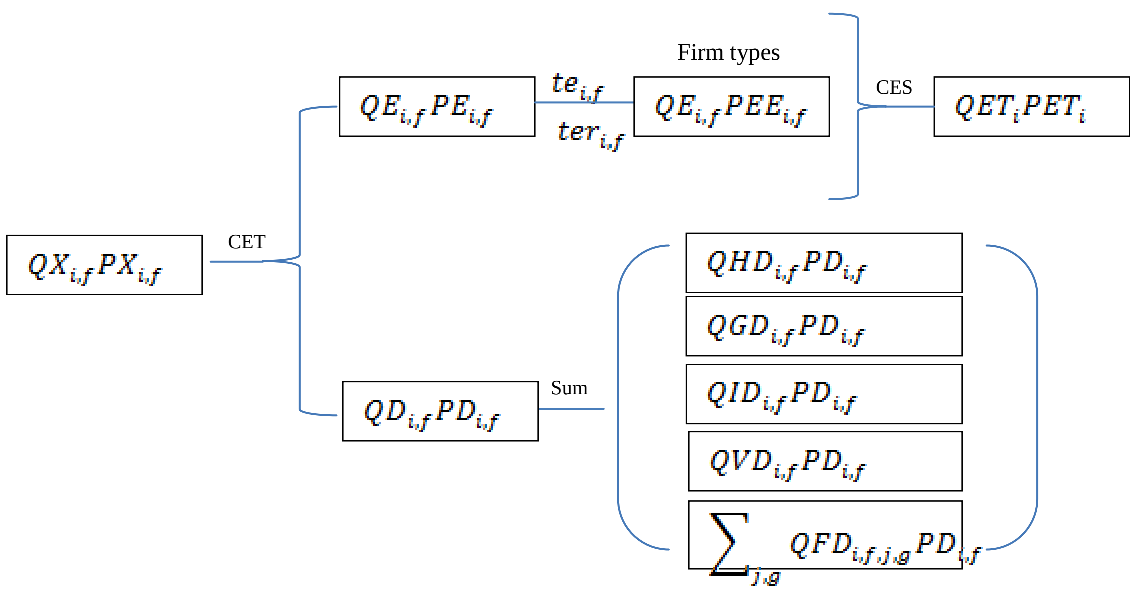
Taking into account the impact of China's dual trade regime, and its impact on different firms due to different dependence on imported inputs (and can be processing imports or nomral imports), each typical firm faces different import tariff, consumption tax and VAT (as shown in Table 3). In contrast, it is assumed (for simplicity and data constraints) that firms receive identical tax policy when purchasing domestic intermediates, meaning that firms pay the same rates of consumption tax and VAT.



Armington assumption is adopted for the incomplete substitution of intermediates supplied by different firm types (*i*, *f*) and imports, $iocf_{j,i,f}QX_{i,f}PINT_{j,i,f}$, i.e. a nested CES structure is used (see Figure above).

3.2 Commodity Market /Trade

As for each firm, its output is allocated between exports and domestic sales on the assumption that suppliers maximize sales revenue for any given output level, subject to imperfect transformability between exports and domestic sales, expressed by a constant elasticity of transformation (CET) function. In the international markets, the small-country assumption is maintained for exports. The price received by domestic suppliers for exports is expressed in domestic currency, including export taxes and export rebate (if any). Domestic sale is made up of the sum of demands on domestic goods for household consumption, government consumption, investment and intermediate inputs.



It is noted that, the initial export price would be $PE_{i,f}$, and arrived at $PEE_{i,f}$ after adding export tax and deducting export rebate, that is

$$PEE_{i,f} = \frac{PE_{i,f}}{1 - te_{i,f} + ter_{i,f}}$$

Assuming the world price for export is PWE_i, defining the exchange rate as EXR, then the export demand in world market would be,

$$QET_i = B_i^E \left(\frac{PET_i}{PWE_i EXR_i}\right)^{-\theta_i}$$

Next, the exports supplied by each type of firm can be determined by respective prices. In formula, we can obtain exports by each type of firm using first order derivative of the CES function given below

$$QE_{i,f} = (A_i^E)^{\sigma_i^E - 1} \left(\delta_{i,f}^E \frac{PET_i}{PEE_{i,f}} \right)^{\sigma_i^E} QET_i$$

Where, the base for calculating export tax and export tax rebate for each type of firm would be the FOB (free on board) price, given by

$$QE_{i,f} PEE_{i,f} te_{i,f}$$

$$QE_{i,f} PEE_{i,f} ter_{i,f}$$

Total supply for domestic uses consist of various final demanders and intermediate uses, i.e.,

$$QD_{i,f} = QHD_{i,f} + QGD_{i,f} + QID_{i,f} + QVD_{i,f} + \sum_{j,g} QFD_{i,f,g,j}$$

Thus, from the perspective of total demand, it equals to the sum of exports and domestic demand,

$$QX_{i,f} = QE_{i,f} + QD_{i,f}$$

On the other hand, from the perspective of total supply, it is governed by the CES production function as given above,

$$QX_{i,f} = A_{i,f}^X \left(\delta_{i,f}^X QL_{i,f}^{\rho_i} + (1 - \delta_{i,f}^X) QK_{i,f}^{\rho_i} \right)^{1/\rho_i}$$

Equating supply and demand via market clearance condition, we can solve for the equilibrium price $PX_{i,f}$.

3.3. Imports and taxes

As mentioned above, due to different policy and dual trade regime, each type of firm, final users and/or investors face different tariff, consumption tax and VAT. Defining PWM_i as the import price, $tfm_{j,f}$ the import tariff of imported goods, $tfmc_{j,f}$ the consumption tax of imported products, and $tfmv_{j,f}$ the VAT of imported goods, then the imported inputs price faced by firms would be,

$$PFM_{i,f} = PWM_i EXR(1 + tfm_{i,f})\left(1 + \frac{tfmc_{i,f}}{1 - tfmc_{i,f}}\right)(1 + tfmv_{i,f})$$

In a similar fashion, we can get imported inputs price received by different final demanders (consumers (H, h), government (G, g), or investors (I,i)), given various taxes levied on imported goods (noting that import demand of stock changes is assumed to be zero),

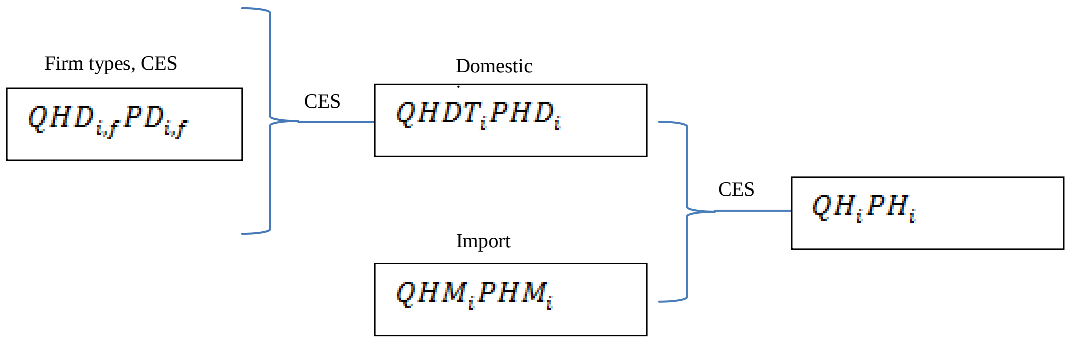
$$PHM_{i,f} = PWM_i EXR(1 + thm_{i,f})\left(1 + \frac{thmc_{i,f}}{1 - thmc_{i,f}}\right)(1 + thmv_{i,f})$$

$$PGM_{i,f} = PWM_i EXR(1 + tgm_{i,f})\left(1 + \frac{tgmc_{i,f}}{1 - tgmc_{i,f}}\right)(1 + tgmv_{i,f})$$

$$PIM_{i,f} = PWM_i EXR(1 + tim_{i,f})\left(1 + \frac{timc_{i,f}}{1 - timc_{i,f}}\right)(1 + timv_{i,f})$$

3.4 Income distribution /Final Demand

Despite producers, there are final demands consisting of households consumption, government expenditure, fixed capital formation (for simplicity, stock changes are assumed to be exogenous). Similar to the treatment of intermediates, final demand also adopts Armington assumption and governed by nested CES function. Taking household consumption for example, the structure is given below.



Saving enters the utility function with the consumer price index as price, representing the opportunity cost of giving up current consumption in exchange for future consumption. The government collects tax from producers, e.g. value-added tax, business tax, other indirect production tax, resident income tax, corporate income tax and import tariff. The government uses this income to purchase commodities for its consumption and for transfers to other institutions.

3.5 Macro closure

Macro closure determines the manner in which the following three accounts are brought into balance: (i) the government budget; (ii) aggregate savings and investment; and (iii) the balance of payments. For the government balance, all tax rates, transfers and government real spending are exogenous in the model, while government real savings is endogenous. For the Savings-Investment balance, the aggregate investment is the endogenous sum of the separate saving components. For the external balance, that the real exchange rate is flexible while foreign savings (the current account deficit) is fixed and exchange rate is chosen as the model numéraire.

Thus far, the basic model has been formulated. To summarize, we have explicitly accounted for heterogeneous production technologies showing up in China's dual trade regime. This model has the property of flexibility for incorporating different types of distortions, such as conventional taxes (e.g., input taxes like import tariff and value added tax, and output taxes), and tax equivalent barriers (e.g., non-tariff barriers to trade). Next, we will show the advantageous features about the model by means of a tax reform example.

4. Simulation

4.1 Policy background

Value added tax (VAT) is an important source of government tax revenue. In 2012, the VAT and consumption tax levied on imports collected by China Customs reached 1,480 billion Yuan, accounting for 14.7% of China's total tax revenue. In contrast, import tariff was 278 billion, which accounted for about 2.8% of total tax revenue. Therefore, the design of a cost-effective tax system is undoubtedly of great significance for China's economic and trade development.

In fact, the export tax rebate policy has played a special and important role among China's trade policies in the past three decades, which has greatly promoted the development of China's processing trade. Along with China's trade status gradually upgrades from the low-end to high-end value chain, do the existing export tax rebate policy need to change? If so, what would be the appropriate alternative? More specifically, which industries should be the priorities? In the context of trade liberalization, what would be the cost and benefit of imported intermediates liberalization, i.e. applying duty-free and VAT-exempt from processing trade to all trade activities? Which sectors will benefit/lose from this policy change? And what would be the impact on China's national fiscal revenue, industrial upgrading and economic restructuring? These are relevant policy issues facing by the authorities.

This study aims to take a new look of China's current export tax rebate policy. Then, by means of investigating the relationship between tax policy and industrial development and upgrade, we will evaluate the tax reform and design alternative policy instruments, to help China's enterprises to enhance the status and participation in the global value chain, thus stepping over the middle-income trap.

Currently, global production networks spread to almost everywhere of the world, which not only has great impact on economic and social development, but also has brought new challenges for policy makers. Take China as an example, within just a decade between 2000 and 2009, its total exports of goods exceeded the seven major industrialized economies (G7 countries), including Japan, the United States, Germany, became the largest exporter and largest goods trading nation. In conjunction with the phenomenal growth, what kind of challenge wills China's taxation, trade, and industrial policy face? Is there a need to adjust? Along with deepening and broadening of globalization both for production and trade, what roles should policies play? These are relevant questions and issues policy makers pressingly concerned under the background of developing of global value chain.

As one of the world's most important value chain participants, China's own development has been intimately linked with world economy. Macroeconomic policy changes or fluctuations in the world will have impact on China's economic and social development through global value chain networks. On the other hand, China's taxation, trade policy, will affect its position and role in the global value chain, thereby has impact on the world economy. Taking into account the sheer difference between China's processing trade regime and normal trade (see above-mentioned Table 1), the extended CGE model pays special attention to capture the heterogeneity. In this way, it is made possible to simulate the effects of export tax rebate policy, serving as quantitative basis for alternative policy instruments design.

4.2 Calibration

It is noted that, CES and/or CET functions with CRTS can be completely characterized by a single point consisting of *input quantities* and *output quantities*, and their *associated prices*, as well as the *elasticity of substitution* and/or *transformation* (there may be several levels of substitution elasticities, thus a nested production structure). One of the main advancements of this work is that, input quantities come from survey-based information rather than proportionality assumption. This is essential to calibrate the benchmark CGE model, as it better captures the "genuine" production structure.

The 2010 extended IO table relies heavily on economic census data and customs data respectively taken by NBS and China Custom (see Tang et al., 2014).[3] To large extent, this effort eliminates shortcomings of proportionality assumption as used widely in the literature and

[3] Instead of six different types of firms in the IO table as given in Tang et al. (2014), for practical reasons, we have aggregated across firm size, resulting in three types of firms.

practice (see Feenstra and Jensen, 2012). Thus, this table serves as starting point for calibration work. Specifically, the 2010 extended IO table is a commodity by commodity type of IO table, consists of agriculture sector, 21 manufacturing sectors, and 20 service-related sectors totaling of 42 sectors (see Appendix A for sector classifications). The values are expressed in producers' price (in year 2010's 10,000 Yuan). In addition, there are four components in value added, namely labor compensation, capital rent, operating surplus, and net taxes (taxes minus subsidies).

Using micro data from NBS and China Customs, the following information is obtained: HS code, tariff line, VAT of imports, consumption tax rate of imported goods (incl. *ad valorem* and), and export tariff rates. Next, we computed import tariff and export tariff using the raw data provided by China Customs. As noted previously, the VAT and consumption tax account for even bigger share of tax revenue than tariff, and those taxes only levy on normal trade. And statistics show that, in 2012, the VAT and consumption tax levied on imports collected by China Customs reached 1,480 billion Yuan, accounting for 14.7% of China's total tax revenue. In contrast, import tariff was 278 billion, which accounted for about 2.8% of total tax revenue. Moreover, due to special rules and regulations for processing trade, processing imports enter China duty-free, i.e. cif (cost, insurance, and freight) price prevails; whereas, normal imports face import tariff, i.e. cif gross of import tariff, plus VAT and consumption tax. Thus, different prices are received by FIE class production (relatively lower price) and other production (relatively higher price).

4.3 Counterfactual experiments and policy implications

Labor is assumed to be mobile across sectors and different technologies, while capital is assumed to be technology-specific factor, a typical short-run assumption in trade literature (very much like the specific-factor model). Therefore, labor will move from one sector to another (and across technology) to equalize the wage payments, while rents are to be adjusted to ensure the full-employment of capital. Our counterfactual experiment contrasts the results with conventional model which overlooks the heterogeneous production technology. The simulation looks into the scenario that all import tariffs were eliminated.

5. Discussions and future extensions

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Appendix A:

Classification of China's 2010 extended Input-Output Table with 42 Sectors

Code	Sector Description	Code	Sector Description
01	Agriculture	22	Scrap and waste
02	Coal mining, washing and processing	23	Electricity and heating power production and supply
03	Crude petroleum and natural gas products	24	Gas production and supply
04	Metal ore mining	25	Water production and supply
05	Non-ferrous mineral mining and other mining	26	Construction
06	Manufacture of food; and wine, spirits , tabacco and soft drinks products	27	Transport and warehousing
07	Textiles production	28	Post
08	Wearing apparel and related products	29	Information communication, computer service and software
09	Products of wood, bamboo, cane, palm, straw; Sawmills and furniture	30	Wholesale and retail trade
10	Stationery and related products	31	Accommodation and restaurants
11	Petroleum processing, coking and nuclear fuel processing	32	Finance and insurance
12	Chemicals and products	33	Real estate
13	Nonmetal Mineral Products	34	Renting and commercial service
14	Metal smelting and pressing	35	Research and development
15	Nonferrous metal smelting and pressing	36	General technical services
16	Metal products	37	Water conservancy, environmental management, and public facility management
17	Manufacture of general purpose machinery and Special equipment	38	Resident services and other services
18	Transport equipment	39	Education
19	Electric equipment and machinery	40	Health service, social guarantee and social welfare
20	Telecommunication equipment, Electronic computer, radar and broadcasting equipment manufacturing; Electronic element and device	41	Culture, sports and amusements

Code	Sector Description	Code	Sector Description
21	Cultural and office equipment, Craft and other manufacturing products	42	Public management and social administration