The bias in accounting for national income changes: when pervasive processing trade is present

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Abstract: The constrains and drawbacks of using ordinary input-output (IO) analysis to account for various changes have long been recognized. However, three problems have implicitly been overlooked in applying so-called structural decomposition analysis (SDA). Specifically, we refine the methodology (i) by taking substitution between primary input and intermediate input into account; (ii) by considering substitution within intermediate inputs; and (iii) by considering substitution between domestic and imported inputs within each element. The methodology is adopted to a case study of China's national income change using extended IO tables that explicitly distinguish processing trade from ordinary production for exports. The contribution of export growth to value added generation is found to be roughly one-third smaller compared with results obtained via using ordinary IO tables. At the industry level the difference is even more striking; for "high-tech" industries that mainly produce instrument related goods the bias in measuring the export contribution to value added growth is as high as four-fifth. These results may also be relevant to other developing countries with considerable processing trade.

Keywords: input-output; national income; processing trade; structural decomposition analysis (SDA)

JEL Codes: C67; F14; O47

1. Introduction

China's rapid economic growth has attracted much attention both from academia and practitioners. Even obvious observation would be that China benefits from the policy of opening-up to the outside world that started in the late 1970s. Ever since, the trade volume has boomed. It grew from $206 billion in 1978 to over $2561 billion in 2008, and the ratio of trade to gross domestic product (GDP) peaked 64% in 2007 (contracted to 61% in 2008, partly due to the global financial crisis). In fact, the average annual growth rate of China's trade is as high as 17% from 1978 till 2008 (compared with 8% for the world as a whole). To a large extent, the sharp increase of trade triggers China's economic growth, as suggested in previous studies on direct evidence for contribution of international trade to economic growth (Feder, 1982; Harrison, 1996; Winters, 2004; Awokuse, 2007).[1]

In the same time, the processing trade[2] finds its way in China. This particular trade pattern began to dominate China's trade in 1996 when it took a portion of 51% of total trade. Researchers started to take processing trade into account because it became inevitable when studying trade (Chen et al., 2001; 2009). It dates back to China's trade policy, which aims at attracting foreign-invested enterprises (FIEs) to China. The FIEs export more than half of China's total export (55% in 2008) and most of them are processing exports. By definition, processing export is normally an assemble of imported materials, even packaged accessaries, which involves limited domestic input of labor and capital, resulting in fewer domestic content generation than ordinary exports do. In consequence, domestic content estimation needs further refinement (Chen et al., 2001; 2009; Lau et al., 2007), echos by Koopman *et al.* (Koopman et al., 2008).[3]

[1] In similar vein, it is documented that trade benefits economic growth, not only in the way of providing more varieties to increase utility (Krugman, 1979; Hummels and Klenow, 2005; Feenstra, 2006), but also by facilitating diffusion of knowledge and technological advance (Coe and Helpman, 1995; Connolly, 2003; Schneider, 2005; Broda and Weinstein, 2006; Bos et al., 2009).

[2] Distinguished from ordinary trade, processing trade uses all or part of the raw and auxiliary materials, parts and components, accessories, and even packaging materials which are imported from abroad duty-free, and after the simply processing or assembling the finished products are re-exported. The imported goods registered as processing trade can only be used to produce exported products, any other means to use such products is prohibited according to the Chinese regulations.

[3] See also, Daudin et al., 2008; Johnson and Noguera, 2010.

Lately, due to the global financial crisis, China's exports dropped precipitously, with 16% contracting on a year-over-year basis for 2009.[4] According to the statistics authority, such decrease led to a big drag on China's economic growth. The magnitude of the impact is estimated to be 3.9%, meaning that to achieve the growth rate of 8.7% the total domestic demand contributed 12.6%, which is highest within last decade. As mentioned earlier, processing trade is different from its ordinary counterpart, so simply summing all exports without considering the difference would yield biased estimates. Take the different types of imports growth for example, the ordinary imports decreased by 6.7 percent while the processing imports decreased by 14.8 percent. Since processing trade has a relatively short production chain in the host country, these observations motivate our investigation of national income changes such that it takes account of processing trade, i.e. to distinguish different production structures explicitly within one framework.

While some studies provide insights in the issue of estimating the contribution of trade to value added generation, few people have tackled the accounting problem yet. To be precise, neither the change nor the trend of the contribution of trade to GDP growth has been intensively studied to date,[5] specifically distinguishing two production structures via considering the processing trade. Previous research dealing with national income change accounting mainly are structural decomposition analysis (SDA) based on input-output (IO) tables (see Rose and Casler, 1996 for a nice overview). And for national income change accounting, there is plenty of literature in using SDA (see for instance, Oosterhaven and van der Linden, 1997; Oosterhaven and Hoen, 1998). As mentioned in the preceding section, much has changed and the progress facilitates the development in both methodologies (theories) and data.

Precisely, we further develop the SDA methodology in three dimensions: firstly, we take account of the substitution between primary input and intermediate input; secondly, we consider substitution within intermediate inputs, adopting the normalized technical coefficients to remedy the dependence problem (as reported in Dietzenbacher and Los, 2000); and thirdly we consider substitution between "home" and "foreign" within each element, the so-called Armington approach (Armington, 1969). This has been widely used in previous studies, Oosterhaven and van der

[4] Meanwhile, the import is reported to have a 11.2% decrease for 2009 compared with 2008.
[5] We use GDP and value added interchangeably in this paper. But a warning is in order: the value added can relate to one industry while only in aggregate equals GDP.

Linden (1997), Oosterhaven and Hoen (1998) for example. Furthermore, the unique IO tables capturing China's processing exports developed by Chen et al. (2001; 2009) and Lau et al. (2007) enables us partition national variables into a processing part and a non-processing part.

Combining the refinement of SDA methodology, and using the special Chinese IO Tables, we are able to address the accounting issue nicely and present it in a straightforward way. One striking finding is that the exports' contribution to value added growth would be exaggerated by no less than one-third[6] when using ordinary IO tables rather than the extended counterparts which distinguish processing exports. This result is in line with other studies on exports' effect, for example the value added generation (Chen et al., 2001; 2009; Lau et al., 2007; Koopman et al., 2008), CO_2 emissions (Dietzenbacher et al., 2009), the bias in measuring vertical specialization (Yang et al., 2009), among others. What's more, we document the trap existing in prevail argument about "high-tech" industries. Particularly, it is found that the bias in measuring overall exports' contribution (both level and structure) to value added growth is as high as four-fifth in industry level (for *Telecommunication equipment, computer and other electronic equipment*, industry 18), which is even more striking. This finding is in sharp contrast to previous studies, for example Andreosso-O'Callaghan and Yue (2002) who draw opposite conclusion due to unable to capture the processing trade.

Despite the so-called polar decomposition methodology (see Dietzenbacher and Los, 1998, among others), the multiplicative decomposition exercise (see Yang and Lahr, 2008; Dietzenbacher et al., 2000) is also performed as a robustness check. The overall conclusion still holds. Regarding large variations in each component's contributions to the growth of value added at the levels of individual products, the contributions calculated using the absolute values of each industry are given. For related investigation, for instance, more and more attention is paid to energy use nowadays, while some emerging economies are boom in exports, they rely much on imports (Hummels et al., 2001). So if such feature is failed to capture in the estimation of energy use for exports production (so the energy use change accounting),

[6] This is given by the so-called *overall percentage error*, measured as results obtained by using extended IO Tables minus those by ordinary counterparts and then over the former, as in Miller and Blair (2009). Here, $OPE=[abs.(16.2-21.8)/16.2]*100=35$.

biased estimation would be resulted. It is relevant to those countries performing substantial processing trade (say, Mexico, see Johnson and Noguera, 2010).

Next we will provide information on data collection and processing. In section 3 the model and formula are given, in particular, we extend Leontief model to capture the processing trade. We present the results in section 4. Section 5 concludes and discusses.

2. Dataset and processing method

The basic datasets are China's official IO Tables for years 1995 and 2002 released by National Bureau of Statistics (see Figure 1). The problem for the official IO tables is obvious, i.e. no distinction is made for which comes from within China and which comes from abroad.

Figure 1 about here

In Figure 1, for row-wise we have **Z** defined as intermediate deliveries matrix, with its element z_{ij} indicating the shipments from (worldwide) industry *i* to industry *j*; Analogously, the vector **f** gives the products consumed by domestic final consumers,[7] and its element f_i representing which fraction of products in (worldwide) industry *i* is directed to final users. In the same fashion, vector of export **e** is defined. Then the vector $\mathbf{x}^M$ is denoted for the imports, its element x_i^M gives the total import (either for intermediate use or final use) of industry *i*. **v**, vector with gross value added at market prices per sector.[8] At last, we have the vector for total output **x**, and its elements are defined accordingly. The prime indicates transposition.

It is customary to deflate the prices to achieve constant prices before the comparison is made. Preferably, aggregation after deflation, and that is the way we

[7] The domestic final uses include rural household consumption, urban household consumption, government expenditure, gross fixed capital formation and changes in inventory. They are of interest themselves, but our focus is the role of exports, so without losing generality we just present one aggregate column in this study.
[8] For primary input, i.e. the gross value added, we have compensation for employees, depreciation of fixed assets, net taxes on production and operating surplus. Here, we focus on the overall impact, so the aggregated value added column is used.

processed the 1995 IO table and 2002 IO table to 2000 constant prices. In such way, the technical coefficient would be "real" technical coefficient which will be comparable to physical scenario (Miller and Blair, 2009). However, since the price index is not readily available especially at disaggregate level, some may prefer to use current price. As studies by Oosterhaven and van der Linden (1997) using nominal price compared to Oosterhaven and Hoen (1998) applying constant price, it is found that the effects of macro economic factors are upward biased, whereas that of coefficient changes are underestimated.[9]

In principle, the RAS procedure for deflation should be applied (see Dietzenbacher and Hoen, 1998), given the price indices for both intermediate deliveries and value added are available. However, all the price index we can get is one for a whole industry, so we have to use the so-called double deflation method (as used elsewhere in literature, see for example Dietzenbacher and Los, 2000; Miller and Blair, 2009; Oosterhaven and Hoen, 1998). And all the prices are adjusted to 2000 prices. In the following we will give information on the collection of price index and the deflating procedure.

For agriculture sector, no ideal price index is available, so by approximation, it is poxied by producer price index (PPI) of agriculture products from *China Statistics Yearbook*. The ex-factory's price index from *2006 China Urban Life and Price Yearbook* in secondary industries is adopted to match the corresponding ones. For those sectors not match exactly the industries in the yearbook, the weighted average approximation is applied. Given the fact that no ideal price index is available for construction and tertiary industries, we use price index of fixed capital investment to substitute the former while use consumer price index (CPI) of different categories to proxy the latter (all data are from *China Statistics Yearbook*).

After obtaining these deflators, we first multiply each industry (row-wise) by its corresponding deflator. This is done for both intermediate uses and final uses. At last, the values added are treated as the "residual", which are computed by subtracting the total intermediate inputs in constant price from the constant total inputs for each industry. Since the value added is a residual term, some error may be occurred.

[9] For completeness, we have applied both methods, i.e. based on constant prices and nominal prices. Our findings are in line with previous research. The results by employing nominal prices are omitted due to space constraint, but available upon request.

However, it is the best estimation we can make, still our results should be interpreted with caution.

The IO tables we use in this study are for year 1995 and year 2002. One problem emerges regarding different industry classifications, i.e. 33 sectors in 1995 table while 42 sectors in 2002 table, it is necessary to compile a concordance table to match those sectors from different years and then to adjust and aggregate them. As mentioned earlier, the aggregation is done only after the deflation procedure. Finally, both 1995 table and 2002 table are aggregated to 28 sectors (industry details are given in the Appendix A1).

The nice thing about our study is that we have the raw data that distinguishes processing trade prepared by Prof. Xikang Chen and his research team (Chen et al., 2001; 2009; Lau et al., 2007). In such way, we are able to extend the standard IO model to incorporate processing trade. Because we have separate effects within one framework. As can be seen from Figure 2, it is rather like the interregional table (Miller and Blair, 2009), we will describe them in detail later.

The reason why we choose 1995 as the starting year is twofold: first, in 1995 the trade pattern started to be dominated by FIEs, who contributed almost 40 percent of China's foreign trade in that year and in consequence the processing trade accounted for more than half of the trade volume; second, the 1995 IO table is the first one distinguishes two production types, namely "domestic and non-processing" type and "processing trade" type (Chen et al., 2001; 2009). 2002 IO table (Lau et al., 2007) advances in several aspects over 1995 IO counterparts, for instance it distinguishes three production structures. Given the superior feature of 2002 IO table, in order to make the two tables comparable, we have to aggregate the 2002 IO table into two production types which is consistent with 1995 table. Now we are in a position to set up the model.

3. Model set-up and formulas

3.1. Basics in the ordinary IO table

As stated in preceding section, the official IO table released by National Bureau of Statistics of China makes no distinction for sources from within China and abroad (see Figure 1). But, as suggested in previous studies (see Oosterhaven and van der

Linden, 1997, for example), the technical coefficient and trade coefficient need to be dealt with separately and explicitly, combination of which yield the domestic input coefficient. From Figure 1, in row-wise we have $\mathbf{x} = \mathbf{Zi} + \mathbf{f} + \mathbf{e} - \mathbf{x}^M$. Define the technical coefficient as matrix **A**, which is given by $\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$ (a hat indicates diagonalization).

Since the coefficient that most relevant for domestic production is the domestic input coefficient, we would like to single it out. Denote **t** the trade coefficient, it is obtained by applying the so-called proportional method (see Pei et al., 2010, and Lahr, 2001 for example). By formula the element of **t** reads: $t_i = x_i^M / (x_i - e_i + x_i^M)$. We further define the input coefficient matrix as $\mathbf{A}^D$, by definition it can be expressed as: $\mathbf{A}^D = (\mathbf{I} - \hat{\mathbf{t}})\mathbf{A}$, with **I** the identity matrix. The Leontief inverse is given by $\mathbf{L} = (\mathbf{I} - \mathbf{A}^D)^{-1} = (\mathbf{I} - (\mathbf{I} - \hat{\mathbf{t}})\mathbf{A})^{-1}$, so the basic solution may be written as $\mathbf{x} = \mathbf{L}(\mathbf{f}^D + \mathbf{e}) = \mathbf{L}((\mathbf{I} - \hat{\mathbf{t}})\mathbf{f} + \mathbf{e})$, with $\mathbf{f}^D$ stands for the domestic final uses supplied by domestic industries.

Till now we have given the basics for total output analysis. However, as pointed out in the literature (see for instance Oosterhaven and van der Linden, 1997), value added is more relevant in terms of policy indication than is total output. Thus, we define **c** as the value-added coefficients, with its elements $c_i = v_i / x_i$. Note that $\mathbf{c'} + \mathbf{i'A} = \mathbf{i'}$, which means changes in primary input coefficients (i.e. change in **c**) not only relates to capital, labor and land, and so forth, but also relates to technological change (i.e. change in **A**, reflecting changes in the mix of intermediate inputs).

So in order to capture such effect, i.e. the substitution between primary input and intermediate input we have $(\mathbf{I} - \hat{\mathbf{c}}) = \mathbf{diag(i'A)}$, recalling $\mathbf{c'} + \mathbf{i'A} = \mathbf{i'}$. Meanwhile, the problem of dependence between components under consideration is reported (see Dietzenbacher and Los, 2000), unfortunately, it is not well solved yet. Especially for the case of value added decomposition study. To amend such problem, one alternative would be to adopt a normalized technical coefficient, denoted $\mathbf{A^n}$. Using the equation we just derived, i.e. $(\mathbf{I} - \hat{\mathbf{c}}) = \mathbf{diag(i'A)}$, we have $\mathbf{A^n} = \mathbf{A}(\mathbf{I} - \hat{\mathbf{c}})^{-1}$, and obviously, $\mathbf{i'A^n} = \mathbf{i'}$. In equations the procedure can be summarized as

$$\mathbf{v} = \hat{\mathbf{c}}(\mathbf{I} - (\mathbf{I} - \hat{\mathbf{t}})\mathbf{A}^n(\mathbf{I} - \hat{\mathbf{c}}))^{-1}(\mathbf{f}^D + \mathbf{e}) \tag{1}$$

Recalling our treatment about the substitution between "home" and "foreign" within cells (Armington assumption), we can re-write formula (1) as

$$\mathbf{v} = \hat{\mathbf{c}}(\mathbf{I} - (\mathbf{I} - \hat{\mathbf{t}})\mathbf{A}^n(\mathbf{I} - \hat{\mathbf{c}}))^{-1}((\mathbf{I} - \hat{\mathbf{t}})\mathbf{f} + \mathbf{e}) \tag{2}$$

One step further, defining $\mathbf{b}^f$ as the bridge coefficient of final demand, which is a vector with preference or taste information; φ^f, is a scalar giving the final uses level. Similarly, denoting $\mathbf{b}^e$ the vector with export composition or structure; φ^e, a scalar with export level. At last, formula (2) can be further extended as

$$\mathbf{v} = \hat{\mathbf{c}}(\mathbf{I} - (\mathbf{I} - \hat{\mathbf{t}})\mathbf{A}^n(\mathbf{I} - \hat{\mathbf{c}}))^{-1}((\mathbf{I} - \hat{\mathbf{t}})\mathbf{b}^f\varphi^f + \mathbf{b}^e\varphi^e) \tag{3}$$

Till now, we have derived the basic formula for value added decomposition in ordinary IO model setting. In equation (3) there are seven components need to be estimated. Apparently, the decomposition analysis can be done immediately by using the tables we have prepared in previous section (see Figure 1).

However, when looking deeper at China's production structure, we find two rather different production or input-output structure coexist, moreover, neither of them can be ignored. As shown in Lau et al. (2007), Koopman et al. (2008), Johnson and Noguera (2010), the presence of processing trade changes conventional perception. Hence, we need to deal with it differently.

3.2. Extending the ordinary IO table to capture processing trade

Previously, we have derived the formula of value added accounting in ordinary IO model setting. So naturally our starting point is China's official IO tables released by National Bureau of Statistics. The single 28×28 technical coefficient matrix $\mathbf{A}$ as given in last section will be used as the basis. To be clear, the extended IO framework is given in Figure 2 as reference.

Figure 2 about here

In Figure 2, it is rather like the interregional IO table (Miller and Blair, 2009). So by simply aggregating the $\mathbf{Z}^{OO}$, $\mathbf{Z}^{MO}$, $\mathbf{Z}^{OP}$, $\mathbf{Z}^{MP}$, we can get the $\mathbf{Z}$ matrix in ordinary IO model setting (Figure 1). In the same fashion, domestic final uses, exports, value added, imports and total output can be obtained. In this extended framework, we have two types of production, namely production for processing exports (*P* type) and other production (than processing exports production), denoted *O* type. According to Chinese regulations, the goods termed as processing trade can only be used for the production of processing exports, which means no domestic sales at all (so we have zeros in according cells).[10]

Recall our aim of estimating the effects of clear distinction of processing trade from normal production on value added accounting. To this end, the following definitions are provided. For superscripts, *O* represents the other production (than processing trade production); *P* stands for processing trade. *OP* means from *O* to *P* (and things alike are defined analogously); a prime indicates transposition. The interpretation for the meanings of intermediate use, final use, exports, and value added are comparable to the ordinary scenario.

Now since we have all the separate effect in hand, it is not difficult to derive the extended formula. Note that values added are explicitly split-up to two parts, respectively the value added of *O* type and *P* type, and so do the exports. To start with, we define $\mathbf{A}^{O}$ and $\mathbf{A}^{P}$ as technical coefficients of *O* type and *P* type, respectively. This is done by adopting Hadamard product to split-up the $\mathbf{A}$ matrix. The accompanying products of this procedure are $\mathbf{\Omega}^{O}$ with its element $\omega_{ij}^{O} = a_{ij}^{O} / a_{ij}$, indicating the relative technology of *O* type; and $\mathbf{\Omega}^{P}$ with its element $\omega_{ij}^{P} = a_{ij}^{P} / a_{ij}$, indicating the relative technology of *P* type.

Analogous to the way we get domestic input coefficient in ordinary IO model, we further split-up technical coefficients of *O* type and *P* type to their domestic input coefficients and imported input coefficients. Define $\mathbf{T}^{O}$, the self-sufficiency ratios of intermediate input, with its elements $t_{ij}^{O} = a_{ij}^{OO} / a_{ij}^{O}$, where $a_{ij}^{OO} = z_{ij}^{OO} / x_{j}^{O}$ expressing the domestic intermediate input coefficient within *O* type. In the same fashion $\mathbf{T}^{P}$ is denoted, its elements are given by $t_{ij}^{P} = a_{ij}^{OP} / a_{ij}^{P}$, where $a_{ij}^{OP} = z_{ij}^{OP} / x_{j}^{P}$ showing the

[10] Full exposition of the development of the extended IO table is beyond the scope of this study. For such respect one can refer to Chen et al., 2001, 2009; Lau et al., 2007.

domestic intermediate input coefficient that *O* type is dedicated for the production of *P* type products.

For final demands, as mentioned earlier, processing exports production is not allowed for domestic sales, so we have zero entry there (see Figure 2). However, domestic final demands come from both within China and abroad. Thus, we need a component to separate them (employing the Armington approach). Define $\mathbf{t}^f$ as the self-sufficiency ratios in final demands, with its elements $t_i^f = f_i^O / f_i$ (and $f_i^O = f_i^D$). In order to distinguish the exports produced by *O* type to *P* type, $\boldsymbol{\tau}^O$ is defined as vector for partition of *O* type within export, with elements determined by $\tau_i^O = e_i^O / e_i$ (so, $i - \tau_i^O = e_i^P / e_i$).

Finally, we can define the relative ratios of value added coefficient of *O* type and *P* type. Define $\mathbf{s}^O$, with its element given by $s^O = c_i^O / c_i$, as the relative ratios of value added coefficient of *O* type, where $c_i^O = v_i^O / x_i^O$; similarly, $\mathbf{s}^P$ is defined (elements are obtained by $s^P = c_i^P / c_i$, and $c_i^P = v_i^P / x_i^P$).

With these definitions in hand, we have the following extended input coefficient and Leontief inverse (as illustrated in Figure 2),

$$\tilde{\mathbf{A}}^D = \begin{bmatrix} \mathbf{A}^{OO} & \mathbf{A}^{OP} \\ \mathbf{0} & \mathbf{0} \end{bmatrix} = \begin{bmatrix} \mathbf{T}^O \otimes \boldsymbol{\Omega}^O \otimes \mathbf{A} & \mathbf{T}^P \otimes \boldsymbol{\Omega}^P \otimes \mathbf{A} \\ \mathbf{0} & \mathbf{0} \end{bmatrix}$$

Further, denote $\mathbf{L}^{OO} = [\mathbf{I} - \mathbf{T}^O \otimes \boldsymbol{\Omega}^O \otimes \mathbf{A}^n (\mathbf{I} - \hat{\mathbf{c}})]^{-1}$, $\mathbf{y}^O = \mathbf{t}^f \otimes \mathbf{b}^f \varphi^f + \boldsymbol{\tau}^O \otimes \mathbf{b}^e \varphi^e$, and $\mathbf{y}^P = \mathbf{e}^P = (\mathbf{i} - \boldsymbol{\tau}^O) \otimes \mathbf{b}^e \varphi^e$, where $\otimes$ is the Hadamard product (of element-by-element multiplication). So the extended Leontief inverse reads

$$\tilde{\mathbf{L}} = (\mathbf{I} - \tilde{\mathbf{A}}^D)^{-1} = \begin{bmatrix} \mathbf{I} - \mathbf{A}^{OO} & -\mathbf{A}^{OP} \\ \mathbf{0} & \mathbf{I} \end{bmatrix}^{-1} = \begin{bmatrix} \mathbf{L}^{OO} & \mathbf{L}^{OO}\mathbf{A}^{OP} \\ \mathbf{0} & \mathbf{I} \end{bmatrix}$$

Finally, $\begin{bmatrix} \mathbf{v}^O \\ \mathbf{v}^P \end{bmatrix} = \begin{bmatrix} \hat{\mathbf{c}}^O & \mathbf{0} \\ \mathbf{0} & \hat{\mathbf{c}}^P \end{bmatrix} \begin{bmatrix} \mathbf{L}^{OO} & \mathbf{L}^{OO}\mathbf{A}^{OP} \\ \mathbf{0} & \mathbf{I} \end{bmatrix} \begin{bmatrix} \mathbf{y}^O \\ \mathbf{e}^P \end{bmatrix}$

After rearrangement, one alternative can be obtained,

$$\mathbf{v} = \mathbf{v}^O + \mathbf{v}^P = \hat{\mathbf{c}}^O \mathbf{L}^{OO} \mathbf{y}^O + \hat{\mathbf{c}}^O \mathbf{L}^{OO} \mathbf{A}^{OP} \mathbf{e}^P + \hat{\mathbf{c}}^P \mathbf{e}^P$$

At last, by substituting and rearranging, we get,

$$
\begin{aligned}
\mathbf{v} &= \hat{\mathbf{s}}^{O}\hat{\mathbf{c}}[\mathbf{I}-\mathbf{T}^{O}\otimes\boldsymbol{\Omega}^{O}\otimes\mathbf{A}^{n}(\mathbf{I}-\hat{\mathbf{c}})]^{-1}(\mathbf{t}^{f}\otimes\mathbf{b}^{f}\varphi^{f}+\boldsymbol{\tau}^{O}\otimes\mathbf{b}^{e}\varphi^{e}) \\
&+\hat{\mathbf{s}}^{O}\hat{\mathbf{c}}[\mathbf{I}-\mathbf{T}^{O}\otimes\boldsymbol{\Omega}^{O}\otimes\mathbf{A}^{n}(\mathbf{I}-\hat{\mathbf{c}})]^{-1}[\mathbf{T}^{P}\otimes\boldsymbol{\Omega}^{P}\otimes\mathbf{A}^{n}(\mathbf{I}-\hat{\mathbf{c}})][(\mathbf{i}-\boldsymbol{\tau}^{O})\otimes\mathbf{b}^{e}\varphi^{e}] \\
&+\hat{\mathbf{s}}^{P}\hat{\mathbf{c}}[(\mathbf{i}-\boldsymbol{\tau}^{O})\otimes\mathbf{b}^{e}\varphi^{e}] \qquad (4)
\end{aligned}
$$

Clearly, the first two parts on the righthand side of the equation yield value added of *other production*, while the third part gives value added of *processing trade*. In this formula we have 14 components that contribute to value added change. Here, we adopt a straightforward way to proceed the decompositions, i.e. employing polar decompositions (see Dietzenbacher and Los, 1998).

3.3. Decomposing the value added changes

It is convenient to give an example about the polar decomposition. Suppose $\mathbf{R}=\mathbf{ST}$, then if we want to investigate the change in **R**, it is possible to ascribe **R**'s change into the components of changes in **S** and **T**. By formula it reads,

$$
\begin{aligned}
\Delta\mathbf{R} &= \mathbf{S}_1\mathbf{T}_1-\mathbf{S}_0\mathbf{T}_0 \\
&= \mathbf{S}_1\mathbf{T}_1-\mathbf{S}_0\mathbf{T}_1+\mathbf{S}_0\mathbf{T}_1-\mathbf{S}_0\mathbf{T}_0=\Delta\mathbf{S}\mathbf{T}_1+\mathbf{S}_0\Delta\mathbf{T} \quad (\textit{one polar}) \qquad (5.1) \\
&= \mathbf{S}_1\mathbf{T}_1-\mathbf{S}_1\mathbf{T}_0+\mathbf{S}_1\mathbf{T}_0-\mathbf{S}_0\mathbf{T}_0=\mathbf{S}_1\Delta\mathbf{T}+\Delta\mathbf{S}\mathbf{T}_0 \quad (\textit{counter-polar}) \qquad (5.2) \\
&= \Delta\mathbf{S}\mathbf{T}_0+\mathbf{S}_0\Delta\mathbf{T}+\Delta\mathbf{S}\Delta\mathbf{T} \qquad (5.3) \\
&= \Delta\mathbf{S}\mathbf{T}_1+\mathbf{S}_1\Delta\mathbf{T}-\Delta\mathbf{S}\Delta\mathbf{T} \qquad (5.4) \\
&= 0.5\,(\mathbf{S}_0+\mathbf{S}_1)\Delta\mathbf{T}+0.5\Delta\mathbf{S}(\mathbf{T}_0+\mathbf{T}_1) \quad (\textit{the average}) \qquad (5.5)
\end{aligned}
$$

Equations (5.1) and (5.2) are equivalent from mathematical point of view, while from economic viewpoint they are using different weights (the so-called *Laspeyres Index* and *Paasche Index*, given by equations (5.3) and (5.4), respectively).[11] Moreover, the index number problem arises in the decomposition formulas, which can be done differently but economically the same (Dietzenbacher and Los, 1998). Following Dietzenbacher and Los (1998), the averages result in good proximation of all possible decompositions in their exercise. With this example in

[11] See Oosterhaven and van der Linden, 1997; Skolka, 1989 for detailed discussion.

hand, the derivation of decomposition formula for equation (4) is trivial (since it seems complicated, we omit it but available upon request).

An alternative way of decomposing the changes in **S** and **T** for the case of $\mathbf{R} = \mathbf{ST}$ would be to use the multiplicative decomposition (Yang and Lahr, 2008; Dietzenbacher et al., 2000). It can be expressed as follows

$$\Delta\mathbf{R} = \mathbf{S}_1\mathbf{T}_1 / \mathbf{S}_0\mathbf{T}_0$$

$$= \underbrace{\frac{\mathbf{S}_1\mathbf{T}_1}{\mathbf{S}_1\mathbf{T}_0}}_{\Delta\mathbf{T}} \times \underbrace{\frac{\mathbf{S}_1\mathbf{T}_0}{\mathbf{S}_0\mathbf{T}_0}}_{\Delta\mathbf{S}} \qquad (\textit{one polar}) \qquad (6.1)$$

$$= \underbrace{\frac{\mathbf{S}_1\mathbf{T}_1}{\mathbf{S}_0\mathbf{T}_1}}_{\Delta\mathbf{S}} \times \underbrace{\frac{\mathbf{S}_0\mathbf{T}_1}{\mathbf{S}_0\mathbf{T}_0}}_{\Delta\mathbf{T}} \qquad (\textit{counter-polar}) \qquad (6.2)$$

$$= \underbrace{\sqrt{\frac{\mathbf{S}_1\mathbf{T}_1}{\mathbf{S}_1\mathbf{T}_0} \times \frac{\mathbf{S}_0\mathbf{T}_1}{\mathbf{S}_0\mathbf{T}_0}}}_{\Delta\mathbf{T}} \times \underbrace{\sqrt{\frac{\mathbf{S}_1\mathbf{T}_0}{\mathbf{S}_0\mathbf{T}_0} \times \frac{\mathbf{S}_1\mathbf{T}_1}{\mathbf{S}_0\mathbf{T}_1}}}_{\Delta\mathbf{S}} \qquad (\textit{the average}) \qquad (6.3)$$

This exercise will be served as a robustness check of our findings that are obtained by applying the additive decompositions.

4. Empirical results by using extended IO framework

China's average annual growth rate of real GDP from 1995 to 2002 is 8.6 per cent (whereas 10.3 per cent in nominal terms).[12] During that period, the population increased for more than 75 million. As in the case of import growth accounting (see Pei et al. 2010), it is reasonable to ascribe large part of GDP growth to sharp increase in demand level. And also trade witnessed tremendous expansion. The increase in value added resulting from advancing foreign trade could be another source to explain the value added growth (Feder, 1982). This is exactly what we find by an immediate computation, for export's contribution in value added, ranges from 12% (18%)[13] in 1995 to 16% (19%) in 2002. On the other hand, the leakage of economy (a scenario simulated what would happen if import would have been produced domestically) is also considerable, for 13% (18%) in 1995 to 14% (17%) in 2002.

[12] Source: China Statistical Yearbook 2008, computed based on Table 2-3 (*GDP at Constant Prices*) and Table 2-1 (*GDP at Current Prices*), respectively.
[13] Figures in parentheses are estimated by using ordinary IO model, which are largely biased.

4.1. Descriptive analysis

Before analysing the empirical results, some descriptive analysis is given. In Table 1 we illustrate the import and export in 1995 and 2002 each industry. Moreover, the share of processing part is also computed.

Table 1 about here

It is clear in Table 1 that processing trade takes dominant position in China's foreign trade. In 1995 and 2002, the processing exports' share are 53% and 48%, respectively. What's more, in 1995 there are ten industries have more than half of export being processing exports, which take roughly one-third of the listed industries. And we observe the industries that show highest processing proportions are mainly industries producing equipment related products. In China these are thought to be high-tech products, and are assumed to be able to generate relatively more value added compared with other traditional industries, for instance textile goods (see for example, Andreosso-O'Callaghan and Yue, 2002). Especially for *Telecommunication equipment, computer and other electronic equipment* (sector 18), the processing export accounts for no less than 85% of its export value, given its eleven percent share of total export.

Similar structure can be found for 2002, but to a lesser extent for the role played by processing export. It is safe to argue that processing activities mainly take place in four industries, which are *Transport equipment* (sector 16) with processing export ratios 76% in 1995 and 50% in 2002, *Electric equipment and machinery* (sector 17) with 85% in 1995 and 66% in 2002, *Telecommunication equipment, computer and other electronic equipment* (sector 18) with 85% in 1995 and 86% in 2002, and *Instruments, meters, cultural and office machinery* (sector 19) with 83% in 1995 and 91% in 2002. These four industries take no less than 17% of total export in 1995, and take about 30% of total exports in 2002, implying rising importance of these sectors in overall export structure. But it is also true that most part of the production of these industries are directed to processing exports, which typically generate limited domestic content.

Now let us turn to the import side. In aggregate level, we see again the downward trend of processing share in overall production, with processing import ratio decreased from 43% in 1995 to 37% in 2002. In industry level, however, we see different structure for processing import compared with processing export. In 1995, the high processing import ratios are more evenly distributed across manufacturing sectors (see Table 1). Not surprisingly, the industry 18 is found to be the second biggest recipient of processing import in 1995 and the largest in 2002.

Referring to previous studies, especially those related to China issue, because they failed to capture the processing trade, biased estimation or misleading conclusion would be resulted. To give some instances, see Andreosso-O'Callaghan and Yue (2002) analyze China's output growth, Guan et al. (2009) account for the changes in China's emissions, and Weber et al. (2009) estimate exports' contribution to China's CO_2 emissions, among others. These research would be sharpened or their results would even be altered when taking into account the processing trade. Recognizing the importance of processing trade, for the first time we will deal with it explicitly to account for China's value added growth.

4.2. Value added changes accounting

Methodologically, we advances in several aspects, as stated previously, for example taking into account the substitution (i) between primary input and intermediate input; (ii) within intermediate inputs; and (iii) between "home" and "foreign" within each element. For dataset, we use the raw IO Tables prepared by Prof. Chen Xikang and his team (Chen et al., 2001; 2009; Lau et al., 2007). In order to make comparison, we also run the program for ordinary IO Tables (released by the NBS China).

To get some brief idea of our findings, we first present the aggregate result in Table 2. At first sight, we observe that technical coefficient (the normalised $\Delta\mathbf{A}^n$), domestic final demands mix, export structure and export level are exaggerated by using ordinary IO model. On the contrary, domestic final demands level is underestimated when ordinary IO model is employed. It worth noting that, however, the magnitude of similar coefficients is compatible, which is not surprising recalling the proposed methodology is applied to the ordinary IO model too.

Table 2 about here

It is clear that the bias in estimating the contribution of export level to value added growth is extraordinarily large, which is no less than 35 percent. So our focus will naturally turn to the interpretation of exports' contribution. There are six extra effects in the extended model due to the presence of pervasive processing trade. These effects in magnitude are relatively small, with one exception the share effect of non-processing export. It contributes 2 percent of value added growth, which makes perfect sense because in reality higher non-processing export share result in more value added generation given per unit export. On the other hand, the contribution of domestic final demands to GDP growth is downward biased by about 5 percent.

In fact, we reallocated the contribution of each effect by means of extended IO model, in this sense it is also true that what we do is *ex post* analysis. In appendix A2, we present the volatility of value added coefficients in industry level, which mimic the big variance in disaggregate sector level. It should be noted that, for 1995 and 2002, the value added coefficients of processing export show relatively unstable feature compared with its counterpart. Therefore, disaggregated results would be more informative and instructive for the sake of policy since huge differences may be hidden (or canceled out) at aggregate level.

4.3. Industry level investigation

Suppose the extended IO tables were not available, we would have been forced to use ordinary IO tables to do the analysis. So in Table 3 and Table 4 we give results at industry level respectively by using ordinary IO table and extended IO table. To start with, the second column in each of the two Tables are the same. The immediate impression would be the uneven growth from one industry to the other, ranging from 902 billion Rmb increase in *commerce* (industry 23) to 104 billion Rmb decrease in *food manufacturing* (industry 6). For industry 23, several observations are of interest. Firstly, apart from the dominant role played by macro-economic factors, the preference or taste change of final consumers accounts for roughly one-fourth of this increase. It clearly indicates an improvement of consumer's bundle, which changes towards higher value added products.

Table 3 about here

Secondly, if the ordinary IO table were used, the export level's contribution ($\Delta\varphi^e$) would have been overstated for roughly one-third, in value it would amount to 36 billion Rmb error (which is 9 times as much as the increase of value added for industry 5, *non-ferrous mineral mining*). Thirdly, the non-processing export share (vector $\Delta\boldsymbol{\tau}^O$) contributes positively with 2% for the overall value added growth. This means the export composition is undergoing change and in the direction of favor value added generation. And this argument is further supported by the export share component (vector $\Delta\mathbf{b}^e$), which would have been reported as 12% in ordinary IO model setting and is 7% in the extended framework.

Next biggest change takes place in sector 1 (agriculture industry), which increased about 670 billion Rmb from 1995 to 2002. In contrast to the previous analysis of commerce, the preference structure of final consumers shifted towards other products and resulted in negative value of -7%. This is perfect sound in the sense that along with increase of income, basic needs such as food will take decreasing share in consumer's overall expenses. Again, the export level's contribution to this increase would be exaggerated by no less than 30% if ordinary IO model would be applied (see Table 3 and Table 4).

As far as *transportation and communication* industry (sector 22) is concerned, the distinguished feature would be the big negative contribution by value added coefficient (vector $\Delta\mathbf{c}$, for -45%). This complies with the rapid growth in technology. For instance, from the perspective of hardware, more highways are constructed and lead to lowering cost for transportation; while from software viewpoint, sharp decrease in price and fast renewal of products enable more efficient and cost-saving communications. In the same time, the export level's contribution would be overstated by roughly one-fifth.

Table 4 about here

Relating to the environment concern, one counter-intuitive observation can be found for the *non-ferrous mineral mining* (sector 5) where the (normalized) technical coefficient, trade coefficient and the bridge coefficient of final demands all tend to drag down the value added generation in this industry. However, when it comes to the reality, this complies with its extensive growth due to the industry policy which in fact encourages the degradation of technology (in such way save the cost).

In contrast, observations from Table 3 and Table 4 for the value added growth pattern in *electricity and heating power production and supply* (industry 11) can be attributed one-third to the technology progress. This partly comes along with China's adaption of advanced technology (in the mean time, using clean energy and shutting-down small inefficient coal mines.) When turning to construction sector (21), we see one-quarter contribution from the value added coefficient, which indicates the upward growth of primary inputs (wages, capital depreciation and so on) in overall share structure.

Till now, we have mainly dealt with industries with big changes in value added from 1995 to 2002. As given in previous section, processing exports dominate four manufacturing industries, i.e. sectors 16 through sector 19 (see Table 1). So naturally we may would like to check the impact of distinguishing processing export to value added accounting. The overall conclusion from comparing Table 3 and Table 4 for these industries would be that such distinction is badly needed. For overall export's (level $\Delta\varphi^e$ plus composition $\Delta\mathbf{b}^e$) contribution, the overstated estimation errors range from one-third to four-fifth, which are striking. Despite this, *Electric equipment and machinery* (industry 17) also presents some interesting feature in the sense that non-processing export share (vector $\Delta\boldsymbol{\tau}^O$) contribute 11% to value added accounting, which is in line with the decreasing share of processing exports in this sector (from 85% in 1995 to 66% in 2002, see Table 1). Obviously, this detail cannot be captured by applying ordinary IO table. Furthermore, it has been rather clear that huge variations would be overlooked when detailed information are absent.

Therefore, in order to substantiate our argument on variation among industries, an alternative computation is conducted. That is the absolute value of all actual sectoral changes (per effect) are aggregated and then the percentage contributions are re-calculated in such scenario (shown in bottom row of Table 3 and Table 4). The surprising figures actually are in accord with our expectation and intuition. In other words, huge variations have been hidden when aggregate effects are used, so in consequence a rush conclusion drawn from such figure may be misleading. In magnitude, the macro-economic factors (levels of final demands and export) contracted about 45% compared with their original percentage values, from 84% and 16% to 45% and 9%, respectively. Still, these are less pronounced than the change in value added coefficient (from -0.7% to 14.5%) and technical coefficient (from 1.3% to 11.0%). Because what we see usually are uneven growth rates both in growth pattern and technology, which are corresponding to value added coefficient and technical coefficient. So in real term they may present opposite impacts on respective industry growth, while in aggregation the difference is likely to cancel out each other. Hence, to account for such impact the absolute value is urgent.

Under this scenario, all the changes are taken into account. Moreover, since the values are computed based on absolute values, it serves as a check for the extent to which the variation influence the aggregate results. In this sense, we see clearly there is need for industry level investigation. Apparently, it gives aggregate estimation, which differs much from its counterparts. The differences in sector level are even big and obvious. These features, however, are hidden from the aggregate of actual values, which further confirms our claim. It is not easy to draw a concise conclusion from these wide differences, so for industry policy, there is not a one-for-all recommendation. Furthermore, as a robustness check, we conducted the multiplicative decompositions for value added accounting,[14] it serves as the evidence that the conclusion holds irrespective whatever methodology is used.

5. Concluding remarks

The presence of pervasive processing trade changes the nature of conventional accounting framework. This study contributes to the literature in two ways: methodologically and empirically. First, three methodology issues are addressed explicitly, which are taking into account the substitution (i) between primary input and intermediate input; (ii) within intermediate inputs; and (iii) between "home" and "foreign" within each production relation unit. Secondly, by using China's extended IO models we are able to explicitly distinguish two types of input-output structure, in which way to extend the basic accounting framework via incorporating the processing part.

[14] The overall conclusion holds, due to space limit the results are not given in the text, but available upon request.

The results have been obtained by incorporating China's distinct production structures. The proposed methodology is adopted to study China's national income change accounting. In line with previous research which indicates overestimate of exports' contribution on value added generation, we find compatible results (35 percent overestimation of export level's contribution in aggregate level). Moreover, the absolute contribution is estimated in order to correct the possible error resulting from aggregation. In such way, the large variations in different products are revealed. Finally, we performed the multiplicative decompositions, which, as robustness check, further confirms our argument.

Last but not least, it is worth noting that the extended SDA formula can easily be reduced to standard form, and can be adopted elsewhere as long as different production structure matters in given context. And also this study is relevant to other developing countries performing considerable processing trade, Mexico for instance (see Johnson and Noguera, 2010).

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Appendix:

A1. Input-output table: sector classifications

IO sector	Description
1	Agriculture
2	Coal mining, washing and processing
3	Crude petroleum and natural gas products
4	Metal ore mining
5	Non-ferrous mineral mining
6	Food manufacturing
7	Textile goods
8	Wearing apparel, leather, furs, down and related products
9	Sawmills and furniture
10	Paper and products, printing and record medium reproduction
11	Electricity and heating power production and supply
12	Petroleum processing, coking and gas products
13	Chemicals
14	Metals smelting and pressing
15	Metal products
16	Transport equipment
17	Electric equipment and machinery
18	Telecommunication equipment, computer and other electronic equipment
19	Instruments, meters, cultural and office machinery
20	Industries not elsewhere classified
21	Construction
22	Transportation and Communication
23	Commerce
24	Accommodation, eating and drinking places
25	Public utilities and household service
26	Cultural, education, health and research
27	Finance and insurance
28	Public management and social administration

A2. Value added coefficients for *processing-export production* and *others*

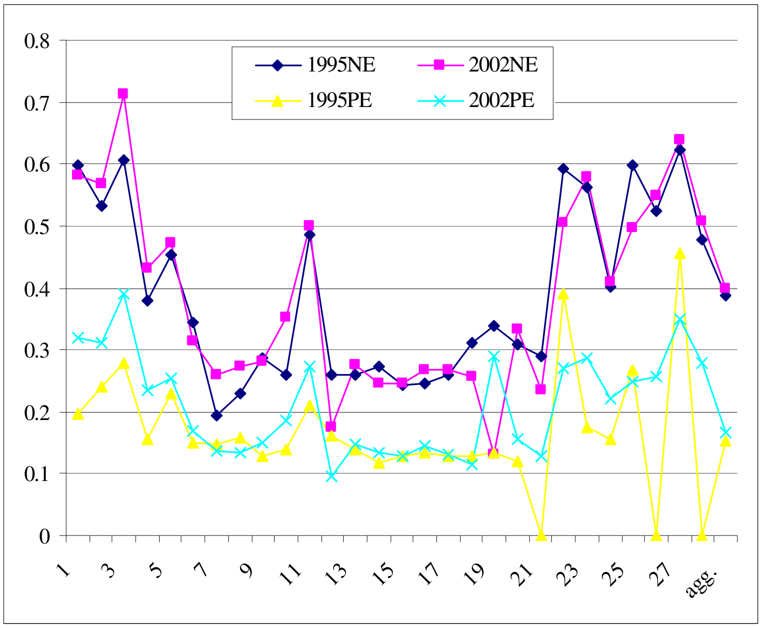

Figure 1. Layout of China's official IO table

	Intermediate use	Final uses		Import	Total Output
		Domestic	*Exports*		
Intermediate use	$\mathbf{Z}$	$\mathbf{f}$	$\mathbf{e}$	$-\mathbf{x}^M$	$\mathbf{x}$
Value Added	$\mathbf{v}'$				
Total Input	$\mathbf{x}'$				

Figure 2. The extended IO framework (processing trade is distinguished)

		Intermediate use		Final uses		Total Output
		Other	*Processing*	*Domestic*	*Exports*	
Intermediate use	*Other*	$\mathbf{Z}^{OO}$	$\mathbf{Z}^{OP}$	$\mathbf{f}^O$	$\mathbf{e}^O$	$\mathbf{x}^O$
	Processing	$\mathbf{0}$	$\mathbf{0}$	$\mathbf{0}$	$\mathbf{e}^P$	$\mathbf{e}^P$
	Imported	$\mathbf{Z}^{MO}$	$\mathbf{Z}^{MP}$	$\mathbf{f}^M$	$\mathbf{0}$	$\mathbf{x}^M$
Value added		$(\mathbf{v}^O)'$	$(\mathbf{v}^P)'$			
Total Input		$(\mathbf{x}^O)'$	$(\mathbf{x}^P)'$			

Notes: *Other* = industries OTHER THAN producing processing exports; *Processing* = industries producing processing exports.

Table 1. Trade and shares of processing component (billion Rmb in current price; %)

code	1995 export	share	2002 export	share	1995 import	share	2002 import	share
1	286	8.0	474	2.7	418	35.2	681	36.7
2	73	9.6	158	0.5	11	6.5	29	0.8
3	98	9.6	121	0.5	98	15.5	1096	3.9
4	26	5.1	19	7.6	161	59.7	367	7.7
5	56	15.0	151	30.6	51	56.7	178	13.4
6	659	21.8	893	26.4	537	44.0	527	23.8
7	1823	36.0	2720	28.9	1046	94.7	1202	62.8
8	1857	65.1	2775	46.4	189	86.8	428	28.5
9	325	41.2	666	41.5	302	22.5	191	53.8
10	753	67.6	987	71.8	178	84.9	547	49.6
11	19	9.6	5	100.0	2	16.3	237	0.0
12	198	7.3	312	20.0	280	7.4	421	38.3
13	1003	40.1	2176	40.1	1662	69.4	3513	43.9
14	527	58.9	461	38.0	969	64.3	1589	61.7
15	438	42.9	1066	46.1	190	67.3	541	72.3
16	227	75.8	653	49.7	482	5.1	1003	22.8
17	583	84.9	2033	66.2	481	74.5	1665	45.7
18	1454	85.5	4968	85.8	1660	50.4	5567	60.5
19	39	83.1	1484	91.1	170	31.5	1611	10.9
20	1395	64.1	2148	37.5	2739	14.7	3569	15.9
21	60	0.0	105	0.5	63	0.0	80	0.0
22	681	43.2	1581	19.1	398	0.0	405	0.0
23	11	53.6	3528	34.9	0	0.0	659	0.0
24	143	36.8	355	36.6	44	0.0	4	0.0
25	142	40.5	835	17.4	30	0.0	408	0.0
26	94	0.0	217	3.3	347	0.0	112	14.8
27	99	53.9	22	100.0	126	0.0	276	0.0
28	54	0.0	30	0.5	45	0.0	37	0.0
total	**13122**	**52.7**	**30943**	**48.1**	**12679**	**43.4**	**26944**	**36.8**

Table 2. National income changes decompositions

	Tot.	$\Delta\mathbf{c}$	$\Delta\mathbf{A}^n$	$\Delta\mathbf{t}$	$\Delta\mathbf{b}^f$	$\Delta\mathbf{b}^e$	$\Delta\varphi^f$	$\Delta\varphi^e$
Ordinary	**5163**	-0.7	1.9	-4.0	2.5	-0.0	78.6	21.8
		$\Delta\mathbf{c}$	$\Delta\mathbf{A}^n$	$\Delta\mathbf{T}^O$	$\Delta\mathbf{t}^f$	$\Delta\mathbf{b}^f$	$\Delta\mathbf{b}^e$	$\Delta\varphi^f$
		-0.7	1.3	-2.6	-2.2	1.6	-1.0	83.5
Extended	**5163**	$\Delta\mathbf{s}^O$	$\Delta\mathbf{s}^P$	$\Delta\mathbf{\Omega}^O$	$\Delta\mathbf{T}^P$	$\Delta\mathbf{\Omega}^P$	$\Delta\boldsymbol{\tau}^O$	$\Delta\varphi^e$
		0.1	0.6	-0.2	1.3	0.4	2.0	16.2

Note: Total value added changes are in billion Rmb (in 2000 constant price); components are in % (add up to 100%). The upper panel and lower panel are respectively obtained by applying ordinary IO model and extended IO model.

Table 3. Results at sector level by using ordinary IO Table

code	$\Delta\mathbf{v}$	$\Delta\mathbf{c}$	$\Delta\mathbf{A}^n$	$\Delta\mathbf{t}$	$\Delta\mathbf{b}^f$	$\Delta\mathbf{b}^e$	$\Delta\varphi^f$	$\Delta\varphi^e$
1	668	21	9	0	-6	-5	68	13
2	153	18	32	-1	15	-2	26	10
3	177	51	21	-3	4	-2	21	9
4	26	25	-9	-12	1	-10	76	29
5	4	161	-700	-264	-174	-11	868	220
6	-104	163	41	-2	160	17	-237	-40
7	-16	128	514	117	88	309	-464	-592
8	79	75	-1	-4	-30	-21	40	42
9	53	0	19	15	-16	-3	60	25
10	100	32	0	-8	-12	-16	68	37
11	267	24	34	-2	5	-2	33	9
12	53	-29	38	9	2	-4	62	23
13	135	-42	-36	-23	-11	-11	149	73
14	56	-150	-105	-23	6	-27	299	100
15	26	-64	-96	-35	-32	1	236	90
16	122	15	-3	1	11	2	60	14
17	45	-20	-40	-49	-22	27	132	71
18	40	-288	28	-94	-44	105	201	193
19	28	-1	8	-42	4	78	16	37
20	202	10	-65	1	-21	-11	147	39
21	347	24	2	-2	0	0	75	1
22	452	-45	24	4	20	1	71	24
23	902	-2	3	-5	25	12	51	16
24	183	-5	30	2	22	1	42	8
25	173	1	-10	-7	4	9	90	14
26	419	13	-2	3	14	0	69	3
27	284	9	30	-3	9	-1	44	11
28	291	17	0	-3	-5	-1	91	1
total (%)	**5163 (100%)**	**-0.7**	**1.9**	**-4.0**	**2.5**	**-0.0**	**78.6**	**21.8**
abs. value (%)	**9558 (100%)**	**15.1**	**11.2**	**3.4**	**9.6**	**4.5**	**43.9**	**12.2**

Note: Changes in value added, billion Rmb; components are in % (add up to 100%).

Table 4. Results by employing the extended IO framework, sector level

code	$\Delta\mathbf{v}$	coefficients												levels	
		$\Delta\mathbf{c}$	$\Delta\mathbf{A}^n$	$\Delta\mathbf{T}^O$	$\Delta\mathbf{t}^f$	$\Delta\mathbf{b}^f$	$\Delta\mathbf{b}^e$	$\Delta\mathbf{s}^O$	$\Delta\mathbf{s}^P$	$\Delta\mathbf{\Omega}^O$	$\Delta\mathbf{T}^P$	$\Delta\mathbf{\Omega}^P$	$\Delta\mathbf{\tau}^O$	$\Delta\varphi^f$	$\Delta\varphi^e$
1	668	21	8	-1	-1	-7	-4	0	0	-1	2	0	1	70	10
2	153	18	32	-1	0	15	-1	0	0	0	0	0	1	28	8
3	177	51	22	-4	0	4	-2	-2	1	0	0	0	1	23	7
4	26	25	-11	-22	-5	0	-8	0	0	13	4	-2	3	85	18
5	4	160	-715	-238	-36	-183	-9	16	5	-2	13	1	11	917	159
6	-104	163	42	1	3	162	16	-1	0	-4	-5	0	-1	-242	-34
7	-16	134	556	111	34	137	241	-29	18	40	-48	-3	-62	-569	-460
8	79	75	-1	-2	-5	-36	-15	-8	6	-1	2	0	7	48	31
9	53	-1	20	11	2	-17	-3	-2	1	2	1	0	0	65	19
10	100	32	-1	-7	-3	-14	-10	-2	1	-3	3	0	1	78	25
11	267	24	33	-3	0	4	-1	0	0	1	0	0	1	35	6
12	53	-29	38	10	-1	2	-4	0	0	-2	0	1	1	66	18
13	135	-42	-39	-29	-7	-14	-10	2	0	5	10	0	5	165	54
14	56	-150	-112	-10	-13	2	-25	-6	0	2	4	1	15	331	60
15	26	-64	-102	-9	-20	-35	-1	9	-1	-7	4	1	4	256	66
16	122	15	-3	4	-2	11	1	-1	0	-3	1	0	3	64	10
17	45	-19	-44	-32	-14	-25	14	10	2	-3	3	0	11	153	45
18	40	-274	37	26	-89	-56	54	39	3	-15	1	0	1	262	111
19	28	-1	7	-25	-8	3	46	-17	44	0	0	0	-3	16	37
20	202	10	-67	6	-6	-22	-8	-6	2	-1	2	0	7	158	26
21	347	24	2	0	-2	0	0	0	0	0	0	0	0	75	1
22	452	-45	24	1	3	20	0	-1	-1	-1	1	2	2	75	20
23	902	-2	3	-3	-2	24	7	2	1	0	1	1	2	54	12
24	183	-5	30	0	2	22	0	-1	0	0	0	0	0	44	6
25	173	1	-10	-8	-1	3	6	-1	1	0	0	1	3	92	11
26	419	13	-2	0	3	14	0	0	0	0	0	0	0	69	3
27	284	9	30	-1	-2	8	-1	-1	0	2	0	-1	0	46	8
28	291	17	0	0	-3	-5	-1	0	0	0	0	0	0	91	1
total (%)	**5163 (100)**	**-0.7**	**1.3**	**-2.6**	**-2.2**	**1.4**	**-1.0**	**0.1**	**0.6**	**-0.2**	**1.3**	**0.4**	**2.0**	**83.5**	**16.2**
abs.%	**9558 (100)**	**14.5**	**11.0**	**2.3**	**1.8**	**9.5**	**2.9**	**1.0**	**0.5**	**0.6**	**0.7**	**0.3**	**1.1**	**44.9**	**8.7**

Note: Changes in value added, billion Rmb; components are in % (add up to 100%).