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## How much did China's emergence as “the world's factory” contribute to its national income?

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### ABSTRACT

Over time, China upgraded its capabilities to such an extent that it requires less imported materials, components, and services to maintain its central role in the global production network. Consequently, the domestic value added content of its exports has increased over time. Still, value added includes profits, which are partly earned by foreign capital owners, many of whom have set up operations in export processing zones. Such profits can be repatriated, and do not directly enhance the living standards in China. This paper will focus on the extent to which China's exporting activities have contributed to its Gross National Income (GNI), which is a better indicator of economy-wide living standards than GDP. Our results, based on input-output analysis, show that the increase in the share of Chinese GNI of a yuan of Chinese exports from 2002 to 2007 was modest, despite a marked growth of Chinese GDP contained in such a yuan of exports. From 2007 to 2017, however, the continued increase of domestic value added per yuan of exports did actually translate into considerably higher contributions of exports to GNI. Decomposition analyses show that changes in the commodity composition of China's export bundle and changes in the shares of national income in value added were the main cause of the different patterns before and after the financial crisis.

### 1. Introduction

Major improvements in information and communication technology, together with trade liberalization and continued reductions in transportation costs, have changed the nature of international trade. Global Value Chains (GVCs) have emerged: the production of consumer goods has become fragmented into several stages that take place in multiple countries, frequently spread over multiple continents (see, e.g. Timmer, Erumban, Los, Stehrer, & de Vries, 2014; Johnson, 2014; Johnson & Noguera, 2017; and Antràs, 2020). China has played a prominent role in these changes. Fueled by its membership of the World Trade Organization since 2001, its well-educated but relatively low-wage workforce and state-led promotion of foreign direct investment (FDI) in processing export activities, China became a central player in the network of GVCs. As the “Factory of the World”, it first exported products like toys and apparel and at a later stage diversified its exports towards higher-end products like consumer electronics (see, e.g., Hanson, 2012).

In this period, Chinese standards of living have improved considerably. It is widely believed that its export performance has played

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a crucial role in this development (Erten & Leight, 2021; Tombe & Zhu, 2019). Different from the existing literature that investigates the role of exports in Chinese GDP (Kee & Tang, 2016; Koopman, Wang, & Wei, 2012), we aim to quantify the contribution of nationwide exports to the growth in China's Gross National Income (GNI) in the period 2002–2017, since GNI is a better indicator to measure living standards than GDP. We adopt an accounting approach, which implies that we do not consider long-run effects due to learning-from-exporting (Bernard & Jensen, 1999; Blalock & Gertler, 2004) or learning-from-inward FDI (Javorcik, 2004; Javorcik & Spatareanu, 2008), which are notoriously hard to estimate. We only focus on the Chinese GNI generated on Chinese territory, and ignore the part of GNI that is due to Chinese outward FDI.<sup>1</sup> Still, just measuring the domestic part of China's GNI attributable to exporting is a challenge. We have to address two major issues: (i) the value of Chinese gross exports is not a good proxy for Chinese value added in its exports, because China imports a lot of intermediate goods and services to produce its exports; and (ii) Chinese value added contained in its exports is not a good proxy for national income due to exports, given the prominence of foreign-owned economic activity in the Chinese economy.<sup>2</sup>

First, intensive participation in GVCs implies that the value of Chinese gross exports is not a good proxy for China's value added induced by exports. The value of gross exports is composed of this “domestic value added” (DVA) and the value of imported intermediate inputs required to produce these exports. Several studies have demonstrated that China generated little DVA per unit of exports in the early stages of its WTO membership (see, e.g., Dean, Fung, & Wang, 2011; Koopman et al., 2012; Ma, Wang, & Zhu, 2015; and Kee & Tang, 2016). This was partly due to the active promotion of the processing exports activities mentioned above. By design, these rely heavily on imports, rather than on materials, parts and components, and services supplied by domestic firms. The accumulated empirical evidence suggests that DVA's share in China's exports started to increase quickly (Chen et al., 2012; Dean et al., 2011; Kee & Tang, 2016; Tang, Wang, & Wang, 2020 and Upward, Wang, & Zheng, 2013). Kee and Tang (2016), who analyzed firm-level data, attributed the marked change to the development of technological and organizational capabilities in China, as a consequence of which firms can produce previously imported intermediate inputs in-house, or source these from domestic suppliers. van Assche and van Biesebroeck (2018) found evidence for similar trends in the processing exports sector in specific. Using Chinese customs data, they show that Chinese activities have shifted from the “Pure Assembly” to the “Import & Assembly” type of export processing, which implies that export processing firms in China have become active in a much broader range of activities than before, including logistics and quality control.

The second problem is the difference between DVA and national income (or, at the economy-wide level, between GDP and GNI). Value added is assigned to the country in which production factors are employed, whereas income is assigned to the country of which the owners of these production factors are citizens. Living standards in China are determined by Chinese GNI rather than by Chinese GDP. The GNI and GDP embodied in Chinese exports are expected to be very different. China's export promotion policies attracted a lot of inward FDI as a consequence of the attractiveness of its processing exports regulations. Duan, Yang, Zhu, and Chen (2012) report that slightly more than 80% of processing exports in 2007 were by foreign-invested enterprises (FIEs, including wholly foreign-owned firms, equity joint ventures and contractual joint ventures), while this share was close to 55% if all exports are considered (Tang et al., 2020).<sup>3</sup> The value added of these firms contains profits, which the FIEs can repatriate. Duan et al. (2012) find that close to 15% of China's DVA in exports does not add to its GNI. Ma et al. (2015), using slightly different data (for 2007 as well), arrive at a share of 12%. Since 2006, however, the share of FIEs in the value of Chinese gross exports has slightly declined.

The dynamics of DVA shares and of FIE shares in exports call for a longitudinal analysis of national income contained in Chinese exports. How did China's export-promoting policies affect national income in the period of rapid international fragmentation of production processes leading to the global production network? After having addressed this question, we decompose the changes to obtain insights into the empirical magnitudes of various drivers of change. The data needed to conduct such a study are basically those used by Duan et al. (2012) and Ma et al. (2015) for 2007. These are high-quality input-output (IO) tables that explicitly make the distinction between the processing exports parts of industries and regular parts of these industries, which is required to arrive at meaningful results. We use the so-called tripartite input-output tables for 2002, 2007, 2012 and 2017 constructed by Chen et al. (2012), Yang et al. (2015) and Chen, Chen, Pei, Yang, and Zhu (2020). Next to these tripartite input-output tables, the estimation of GNI in Chinese exports requires data on investment by firms categorized by ownership (e.g. domestic enterprises vs. FIEs) and

<sup>1</sup> It is worth mentioning that the foreign value added (FVA) in exports would also incorporate some Chinese GNI given that some imported materials (as embodied in Chinese exports) are produced abroad using Chinese outward FDI. If data were available, one could explicitly split both domestic value added (DVA) and FVA in Chinese gross exports by attributing capital income to the countries of ownership. For this, detailed information on the capital structure and input structure of Chinese-owned firms abroad is necessary, which is not available. However, we argue that ignoring the GNI located abroad has a minor impact on our empirical results since the Chinese outward FDI stock is quite small in magnitude compared with the global FDI stock. The ratio is only 2.3% in 2012 according to UNCTAD (United Nations Conference on Trade and Development).

<sup>2</sup> The part of GDP that is embodied in exports is often termed ‘DVA in exports’, and contributions of industries to GDP are often termed ‘value added’. In the same fashion, we use the terms ‘national income in exports’ for the part of GNI that is embodied in exports and ‘national income by industry’ for the contribution of industries in GNI. Similarly, ‘national income in final output of domestic production’ indicates the part of GNI that is embodied in the final output of domestic production.

<sup>3</sup> Wholly foreign-owned firms are established with exclusive investment from foreign investors or investors based in Hong Kong, Macao or Taiwan (HMT). Joint Venture Enterprises and contractual joint ventures are jointly established by foreign or HMT investment with enterprises in mainland China, in accordance with the relevant laws. The sharing of investment, profits and risks is stipulated under contract. See also Zhang and Song (2001) and Zhang (2005). Tang et al. (2020) have estimated the ratio of domestic value-added to gross exports for different firm types in China, including State-Owned Enterprises, Foreign-Owned Enterprises, Large Private Enterprises, and Small and Medium Enterprises. However, they did not study the implications of exports for national income.

assumptions on returns to capital.

The paper proceeds as follows. Section 2 explains the IO framework that we adopt to measure Chinese DVA due to Chinese exports, and the methodology to account for the differences between national income and this DVA in exports. Section 3 gives a detailed description of the data sources. Section 4 provides the empirical results. In Section 5, we quantify the contributions of changes in several exogenous variables to see which tendencies have had the most important effects on changes in the share of Chinese GNI in its exports in the decade between 2002 and 2017. Section 6 focuses on the relative importance of exports in generating China's GNI in the same period. Section 7 concludes.

## 2. Methodology

### 2.1. Deriving national income in exports from a tripartite input-output table

Input-output tables have proven to be a useful vehicle for analyses of the dynamics of growth. Such tables provide quantitative descriptions of the production technologies of the industries of which the economy consists. One of the major assumptions of input-output models based on such tables is that the production technology used to produce a given unit of output of an industry is not dependent on the use of the output. That is, the domestic intermediate input requirements, the imported intermediate input requirements and the payments to production factors are assumed to be identical for the products of an industry, irrespective of whether they are used as intermediate inputs by downstream industries, as consumption goods, as capital goods or as exported products. For countries like Mexico and China, however, this assumption tends to be violated to a much larger extent than elsewhere. This is due to the prevalence of processing exports activities. These activities (which are present in several manufacturing industries) are exempted from tariffs on imported inputs, provided that the output is only sold abroad. The ensuing differences in the relative prices of imported and domestic inputs faced by a processing exports producer and a regular firm in the same industry cause differences in input mixes. Furthermore, processing exports firms are more often foreign-owned than regular producers, which is reflected in differences in the technologies available to both types of producers. Considerable evidence exists that studies that cannot separate China's processing exports activities from other production activities (e.g. production for domestic use) will lead to biased estimates of factor contents of exports (see, e.g., Dean et al., 2011, Koopman et al., 2012, and Pei, Oosterhaven, & Dietzenbacher, 2012).<sup>4</sup>

To reduce this aggregation bias, Chen et al. (2012) developed a tripartite input-output table for China, in which all industries have been split into three 'subindustries': a subindustry for production of Domestic Enterprises (DEs) to meet domestic demand (hereafter 'domestic production'), production for processing exports (hereafter 'processing exports'), and a subindustry in which production for ordinary exports and production of FIEs for domestic use (hereafter 'ordinary exports and other') are merged.<sup>5</sup> The structure of such a tripartite table is shown in Fig. 1.<sup>6</sup>

Given that each industry is divided into three subindustries, the numbers of rows and columns of the intermediate deliveries block  $Z$  are three times as large as in an ordinary IO table. The subscript  $D$  refers to domestic production, while  $P$  indicates processing exports, and  $N$  represents ordinary exports and other subindustries. The rows correspond to subindustries that sell to (at most) three categories of users, which are represented by the columns: subindustries (of the three types) that purchase the output of the row subindustry as intermediate inputs, Chinese households and firms that use this output as consumption products and capital goods, respectively (domestic final demand,  $DFD$ ) and foreign buyers (exports,  $EXP$ ). The block labeled  $IMP$  contains imports. Each row in this block corresponds to a selling industry. The row labeled  $VA$  contains the value added in all subindustries of all three types. The double-entry bookkeeping identity ensures that the sum over all elements in each of the subindustry rows ( $TOT$ ) is equal to the sum over all elements in the corresponding column.

As is reflected in Fig. 1, the split of industries in the  $D$ ,  $P$ , and  $N$  types implies that some blocks of the input-output table exclusively contain zeros. The output of domestic production activities is by definition only sold to domestic users, so the export vector for the  $D$  rows consists of zeros. Furthermore, the intermediate use and domestic final use parts of the  $P$  rows contain zeros, since processing exports are only allowed to produce for foreign markets.

The matrix with domestic intermediate input coefficients  $A$  can be obtained as  $A = Z\hat{x}$ , in which  $\hat{x}$  indicates the diagonal matrix with the elements of the vector  $x$  (which contains the elements of  $x^D$ ,  $x^P$  and  $x^N$ ) on the main diagonal:

$$A = \begin{pmatrix} A^{DD} & A^{DP} & A^{DN} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ A^{ND} & A^{NP} & A^{NN} \end{pmatrix}$$

Each block  $A^{ST}$  indicates the cost shares of output from each subindustry in  $S$  in the value of the output of each subindustry in  $T$ , with  $S = D, P, N$  and  $T = D, P, N$ . This implies that the Leontief inverse for the tripartite table is given by

$$L = (I_{3m} - A)^{-1} = \begin{pmatrix} L^{DD} & L^{DP} & L^{DN} \\ \mathbf{0} & I & \mathbf{0} \\ L^{ND} & L^{NP} & L^{NN} \end{pmatrix}$$

<sup>4</sup> See also Duan et al. (2018), for similar findings regarding the degree of vertical specialization.

<sup>5</sup> Yang et al. (2015) provides detailed information about the data for 'ordinary exports and other'.

<sup>6</sup> The industry classification of the national input-output tables is presented in Appendix A.

		Intermediate use			Final use		TOT
		D	P	N	DFD	EXP	
Supply	D	$\mathbf{Z}^{DD}$	$\mathbf{Z}^{DP}$	$\mathbf{Z}^{DN}$	$\mathbf{f}^D$	$\mathbf{0}$	$\mathbf{x}^D$
	P	$\mathbf{0}$	$\mathbf{0}$	$\mathbf{0}$	$\mathbf{0}$	$\mathbf{e}^P$	$\mathbf{x}^P$
	N	$\mathbf{Z}^{ND}$	$\mathbf{Z}^{NP}$	$\mathbf{Z}^{NN}$	$\mathbf{f}^N$	$\mathbf{e}^N$	$\mathbf{x}^N$
	IMP	$\mathbf{Z}^{MD}$	$\mathbf{Z}^{DP}$	$\mathbf{Z}^{MN}$	$\mathbf{f}^M$		
	VA	$(\mathbf{v}^D)'$	$(\mathbf{v}^P)'$	$(\mathbf{v}^N)'$			
	TOT	$(\mathbf{x}^D)'$	$(\mathbf{x}^P)'$	$(\mathbf{x}^N)'$			

Fig. 1. Schematic outline of China's tripartite input-output table.

Notes: D: domestic production subindustries; P: processing exports subindustries; N: ordinary exports and other subindustries; DFD: domestic final demand; EXP: exports; TOT: gross output; IMP: imports; and VA: value added. The table is expressed in monetary units.

in which  $\mathbf{I}$  stands for the identity matrix and  $m$  represents the number of industries.

As mentioned, the input-output table depicted in Fig. 1 contains information on value added created in each of the subindustries. The cells in the row VA contain value added that partly contributes to GNI (e.g., wages paid to Chinese workers and compensation of capital owned by Chinese investors) and partly not (e.g., wages paid to non-residents and profits accruing to foreign capital owners). If we denote the column vector with value added-to-gross output ratios by  $\mathbf{w}$ , we could split these ratios as  $\mathbf{w} = \mathbf{w}^n + \mathbf{w}^f$ , with:

$$\mathbf{w}^n = \begin{pmatrix} \mathbf{w}^{nD} \\ \mathbf{w}^{nP} \\ \mathbf{w}^{nN} \end{pmatrix} \text{ and } \mathbf{w}^f = \begin{pmatrix} \mathbf{w}^{fD} \\ \mathbf{w}^{fP} \\ \mathbf{w}^{fN} \end{pmatrix}$$

$\mathbf{w}^n$  and  $\mathbf{w}^f$  represent the vector of national income-to-gross output ratios and the vector of foreign income-to-gross output ratios by industry, respectively. Below, we will explain our approach to estimating these splits of the elements in  $\mathbf{w}$  into the elements of  $\mathbf{w}^n$  and  $\mathbf{w}^f$ .

Armed with these definitions and assuming constant returns to scale production functions and homogeneous production techniques within subindustries, we can compute national income induced by the three types of final demand: domestic final demand ( $\mathbf{f}^D$  and  $\mathbf{f}^N$ , see Fig. 1), processing exports ( $\mathbf{e}^P$ ), and ordinary exports ( $\mathbf{e}^N$ ):

$$ni^D = (\mathbf{w}^{nD'} \mathbf{L}^{DD} + \mathbf{w}^{nN'} \mathbf{L}^{ND}) \mathbf{f}^D + (\mathbf{w}^{nD'} \mathbf{L}^{DN} + \mathbf{w}^{nN'} \mathbf{L}^{NN}) \mathbf{f}^N \tag{1}$$

$$ni^P = (\mathbf{w}^{nD'} \mathbf{L}^{DP} + \mathbf{w}^{nP'} + \mathbf{w}^{nN'} \mathbf{L}^{NP}) \mathbf{e}^P \tag{2}$$

$$ni^N = (\mathbf{w}^{nD'} \mathbf{L}^{DN} + \mathbf{w}^{nN'} \mathbf{L}^{NN}) \mathbf{e}^N \tag{3}$$

Eq. (1) gives the GNI generated by domestic final demand. Subindustries in the domestic production sector and the ordinary exports sector contribute to this. Not only subindustries producing final products add to this part of national income, but also subindustries supplying intermediate inputs to these Chinese producers of final products, subindustries supplying to these 'first-tier suppliers', etc. This is reflected by the blocks of the Leontief inverse  $\mathbf{L}$  in (1). In a similar vein, eq. (2) shows that all three types of subindustries create GNI due to the output of processing exports activities. The domestic and ordinary exports subindustries only contribute via upstream activities (delivering intermediate inputs), while the processing exports industries only create GNI in the last stage of production of the exported products. These subindustries do not deliver any intermediate inputs, as was reflected already by the row with zeros in the matrix with intermediate input coefficients,  $\mathbf{A}$ . Eq. (3) indicates the GNI that can be attributed to ordinary exports. The sum of (2) and (3) yields the national income in total exports. The sum of  $ni^P$  and  $ni^N$  will be lower than the sum of the elements in the gross exports vectors  $\mathbf{e}^P$  and  $\mathbf{e}^N$ , since our approach takes into account that such gross exports also contain imported value added and value added that is income earned by foreign firms. Both aspects are important given China's strong involvement in the global production network.

2.2. Estimating national income and foreign income shares in domestic value added

We now turn to splitting value added into national and foreign income. We have to estimate the shares of national income in value

added by (sub)industry ourselves, since such data is not available. Value added in China's input-output tables consists of three parts: (a) taxes, (b) labor income, and (c) capital income, which includes depreciation of fixed assets and profits. Taxes are paid to the Chinese government and are therefore part of China's GNI. We assume that all labor income contributes to GNI, neglecting the small part earned by foreign employees.<sup>7</sup> Hence, we only focus on splitting capital income, since a substantial part of capital income in China consists of returns on foreign capital.

China's Balance of Payments (BOP) provides information about the profits on foreign investment in China. However, the headline figure seriously underestimates the true profits on inward FDI, due to China's incomplete statistics on retained earnings on foreign investment.<sup>8</sup> In re-estimating income on foreign capital, we use an improved version of the method proposed by Duan et al. (2012).<sup>9</sup>

We proceed along the lines depicted in Fig. 2 for the case of production of processing exports. The same procedure applies to the other two cases (i.e. production of domestic outputs and production of 'ordinary exports and other'). The data we use and the assumptions we make will be discussed in the next section. First, we divide the output of each subindustry into output of FIEs and output of DEs. For the domestic production subindustries, this is trivial: by definition, these only consist of Chinese firms and almost all capital income accrues to China.<sup>10</sup> Next, we estimate the capital income of both types of enterprises. We then continue by splitting these capital income levels into foreign capital income and national capital income, and add the respective results for FIEs and DEs to arrive at initial estimates of aggregate foreign capital income and national capital income (in processing exports and in ordinary exports and other separately). These initial estimates might not add up to total capital income as documented in the tripartite input-output tables, because the underlying data are not necessarily consistent with each other. Therefore, a final reconciliation step is needed to ensure that the foreign-owned capital income and national capital income data can be used in an IO framework. A detailed, mathematical exposition of the methods underlying the procedure depicted in Fig. 2 can be found in Appendix A.

### 3. Data

Tripartite input-output tables for China, which were jointly compiled by the National Bureau of Statistics of China (NBS) and the Chinese Academy of Sciences (CAS), are one of our key data sources. Currently, the tripartite tables are available for the years of 2002, 2007, 2012, and 2017.<sup>11</sup> These years mark the rapid emergence of China as the "Factory of the World", after it became a member of the WTO in 2001. Details of the procedures adopted by NBS and CAS to construct the tables have been provided by Chen et al. (2012). Due to limited industry detail in the data required to split capital income according to Fig. 2, we have to sacrifice some detail in the input-output data: we aggregated the 42 industries in the tripartite input-output tables into 30 industries. These include 5 natural resources industries (i.e., agriculture and mining), 16 manufacturing industries, 4 industries related to construction and utilities, and 5 services industries (see Appendix B for details). All data represented by the matrices and vectors depicted in Fig. 1 are contained in these tables.<sup>12</sup>

The tripartite input-output tables for China are also the source for the capital income shares in value added for all subindustries, as used in the last step of the procedure outlined in Fig. 2. The simplified Fig. 1 contains a single row for value added (the vectors  $\mathbf{v}$ ), but the actual tables contain several rows, and a row with capital income is one of these. The capital income shares are simply computed as the ratios between capital income and total value added in each sector. These do not provide information on the split between national capital income and foreign capital income, though.

In the first step (see also Fig. 2), we compute the output shares of FIEs in each subindustry, which is not possible on the basis of input-output data only. For subindustries of the domestic production type, the FIE's share in output is zero, because the definition of domestic production implies that only DEs are active in these subindustries. Hence, we only need to estimate the proportion of FIE output in total output of the processing exports and the ordinary exports and other subindustries. To this end, we employ export statistics from China's Customs Office (also used by Brandt, Van Biesebroeck, Wang, & Zhang, 2017), which are not only classified by

<sup>7</sup> According to the United Nations Global Migration Database, in 2013 the share of foreigners in the total number of people living in China amounted to only 0.06%.

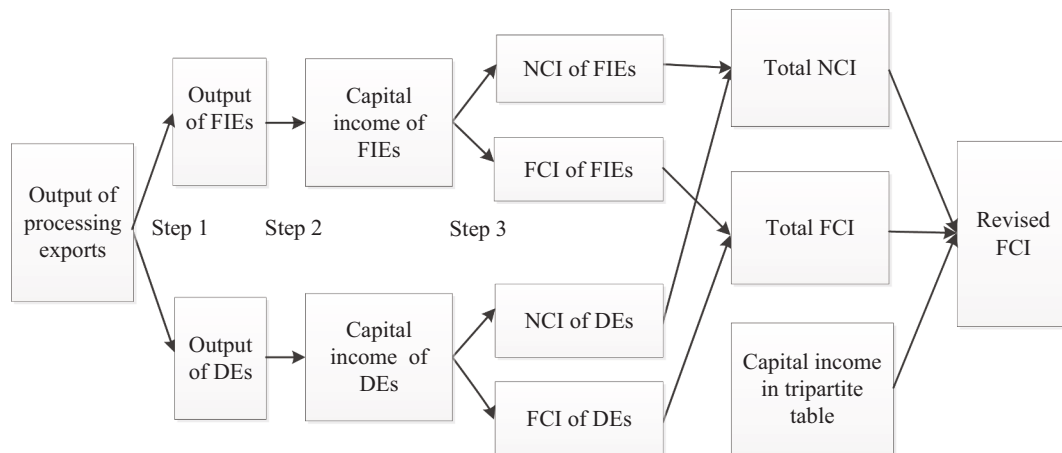
<sup>8</sup> According to the International Monetary Fund (2009), the item Profit from Investment in the BOP statistics should include all profits created by foreign investment, irrespective of whether these remain in the host country or not. Yao's (2008) rough estimate indicates that the real profits of inward FDI in China for 2004–2006 were about four times the value shown in the official BOP statistics.

<sup>9</sup> Duan et al. (2012) assumed that FIEs and DEs have identical capital income to output ratios, which is an implausible assumption (see, e.g. data in NBS, 2008).

<sup>10</sup> By definition, the DEs are established by using Chinese assets. However, in reality, after the establishment of a DE, it is allowable to receive a small fraction of foreign investment without changing the registration type. Therefore, there is some foreign capital invested in DEs. In Lardy, 2007, for example, the foreign capital accounted for 1.2% of all capital invested in DEs in industrial sector (including Mining, Manufacturing, and Supply of electricity, heat, gas and water).

<sup>11</sup> As the tripartite input-output table fails to distinguish the production of DEs and FIEs within the industries of types  $N$  and  $P$ , an implied assumption in this paper is that the production technology (within  $N$  and  $P$ ) is the same for DEs and FIEs. This assumption is reasonable. Ma et al. (2015) have compiled a Chinese national input-output table in Lardy, 2007 by distinguishing between Chinese exports by FIEs and Chinese-owned enterprises (COEs), in addition to processing and normal exports. They find that DVA shares in exports are quite similar between FIEs and COEs within the same trade regime. For example, the DVA shares in processing exports of FIEs and COEs are 37.3% and 35.5% respectively, and those in normal exports of FIEs and COEs are 79.5% and 84.1%, respectively. Their results suggest that distinguishing the production of DEs and FIEs in the IO tables makes little difference for our empirical results.

<sup>12</sup> See Appendix C for a summary table of the data sources described in this section.



**Fig. 2.** Capital income decomposition procedure for production of processing exports. Note: NCI=National capital income; FCI= foreign capital income.

commodity (at the 8-digit HS level), but also by trade regime (e.g. processing exports, ordinary exports) and by enterprise type (FIEs and DEs). We use concordance tables (provided by NBS) between the HS 8-digit commodities and the input-output classifications to split processing exports and ordinary exports of goods into exports of FIEs and exports of DEs. Since statistics for services exports are of relatively poor quality, we have to adopt a rough approximation procedure. For service industries, we assume that the shares of FIEs in exports are identical to the shares of FIEs in total domestic sales.<sup>13</sup> Given that exports of services amounted to just 10.9% and 8.5% of the total Chinese exports value in 2002 and 2012, respectively, our results for the national income attributed to all exports will probably not be very sensitive to this crude assumption.

In the second step, we estimate the capital income-output ratios at subindustry level, for which we employ various data. To compute capital income of FIEs and DEs, we add 'depreciation of fixed assets' to 'operating profits'. For manufacturing industries, these data and (and the output data as well) are sourced from the annual *China Industry Economy Statistical Yearbook*. For services and construction, data on 'operating income' are used to capture the output of FIEs and DEs, which together with capital income data is taken from *China's Economic Census Statistics Yearbook* (NBS, 2006, 2010).<sup>14</sup> We then straightforwardly compute the capital income to output ratios by dividing the capital income by output in each subindustry. For agriculture, facing a lack of more sophisticated data, we obtain the capital income-output ratio from the tripartite tables: we take the capital income-output ratio of the domestic production subindustry as a proxy of that of DEs, while we use the capital income-output ratio of the ordinary exports and others subindustry as estimate of that of FIEs.

Finally, to estimate the foreign-owned capital shares in DEs and FIEs in the third step of Fig. 2's procedure, we use data related to 'paid-in capital' (the asset value of firms).<sup>15</sup> In China's statistics, six categories of paid-in capital are present. Four of these relate to assets financed by various types of Chinese shareholders. The remaining two (HMT paid-in capital and foreign paid-in capital) indicate the value of assets sourced from Hong Kong, Macao and Taiwan and from foreign regions, respectively.<sup>16</sup> We employ the aggregate shares of HMT and foreign paid-in capital in total paid-in capital to measure the foreign-owned capital shares in DEs and FIEs. The

<sup>13</sup> This assumption may underestimate the share of FIEs in total exports, as existing studies (Brakman, Garretsen, van Maarseveen, & Zwaneveld, 2020; Kelle, Kleinert, Raff, & Toubal, 2013) always find that the FIEs have a higher export probability than DEs. As a result, it would underestimate the foreign capital income in value added, and therefore overestimate the Chinese GNI embodied in exports. Therefore, we also use the share of FIEs in total merchandise exports as a proxy of the share of FIEs in service exports. This changes the national income share embodied in Chinese exports only negligibly, from 64.90% to 64.87%. It suggests that our treatment of service exports has a minor impact on our empirical results.

<sup>14</sup> The use of 'operating income' (which measures the total sales of a service sector) is in accordance with the method described in the *Compilation of Chinese Input Output Table 2007* (NBS, 2009).

<sup>15</sup> Paid-in capital refers to the total value of assets actually invested by shareholders. These assets can be currency, physical assets (e.g., equipment, plants) and intangible assets (e.g., technology, patents). Paid-in capital represents the property right of investors to the enterprise, and its composition is the main basis for profits distribution among investors. See: [http://www.stats.gov.cn/tjzd/tjzbs/t20020327\\_14284.htm](http://www.stats.gov.cn/tjzd/tjzbs/t20020327_14284.htm).

<sup>16</sup> The six categories are state paid-in capital, collective paid-in capital, corporation paid-in capital, individual paid-in capital, HMT paid-in capital, and foreign paid-in capital.

paid-in capital data for both FIEs and DEs are taken from the *China Industry Economy Statistical Yearbook* (NBS, 2003; NBS, 2008, 2013, 2018) for manufacturing industries, and from *China's Economic Census Statistics Yearbook* (NBS, 2006, 2010) for services industries.<sup>17</sup>

For the agriculture and construction industries, paid-in capital data are not available. Hence, we use the share of foreign-owned capital in 'registered capital' of FIEs to estimate the foreign-owned capital share of FIEs in these industries.<sup>18</sup> Registered capital refers to the total value of assets invested by shareholders at the time an enterprise has just been established. Consequently, registered capital data will yield biased statistics if compared to the true capital stock, if the origin of later investments is different from the initially provided assets. However, according to Chinese regulation, differences between paid-in capital and registered capital must remain below 20%, otherwise the registered capital data must be updated to conform with paid-in capital, so our estimates cannot be very inaccurate. The registered capital data come from the *China Statistical Yearbook*. For DEs in agriculture and construction, we do not have meaningful data on ownership and assume that capital stocks are fully owned by Chinese.

We should note that the national income concept in this paper and GNI published by the NBS are slightly different from each other, in two respects. First, we only focus on the part of GNI generated on Chinese territory, ignoring the part of GNI due to Chinese outward FDI. Second, GNI as published by the NBS is obtained as the sum of GDP and the net inflow of labor compensation and investment income to China, as documented in China's BOP statistics. However, as mentioned above, China's BOP accounts underestimate the true profits of inward foreign investment severely (Yao, 2008). This leads to our three-step estimation of the returns to inward foreign investment above, which provides a better estimation on national income but also causes divergence from the official statistics. The results show that the GNI estimated in this paper is smaller than that in the official statistics. For example, the ratios of GNI to GDP are 97.4%, 94.4%, 94.1%, and 97.1% in 2002, 2007, 2012, and 2017 according to our estimation, while the ratios are 99.0%, 100.2%, 99.8% and 99.9% in the NBS statistics.

## 4. Results: national income in China's exports

### 4.1. Aggregate national income in exports

Using the methodology set forth in Section 2, we estimate the contents of exports by the two types of subindustries that sell abroad, in 2002, 2007, 2012 and 2017. We present the results in Table 1. The first column (DVA) gives the share of domestic value added in exports.<sup>19</sup> DVA is split into a part that contributes to Chinese national income (the second column) and in a part that consists of foreign income (the fourth column). The third column gives the shares of national income in DVA in exports. Finally, we define the foreign content of exports (in the sixth column) as the sum of foreign income and imported content (fifth column) in exports. By definition, the sum of the DVA share and the imported content share is equal to 1, as is the sum of the national income share and the foreign content share (that is, (1) + (5) = 100 and (2) + (6) = 100 in each row).

A first important finding is that the national income shares in exports were not only considerably lower than the DVA shares in exports, but also developed differently over the decade in which China became a major player in the global production network. In the early stages, from 2002 to 2007, the DVA share in exports increased rapidly by 3.8 percentage points (from 55.4% to 59.2%), reflecting a reduced dependence on imported intermediate inputs. The national income share, however, grew only marginally (0.7 percentage points, from 50.6% to 51.3%) over the same period.<sup>20</sup> Several tendencies can have contributed to these changes: (a) exporting firms may have substituted imported intermediate inputs by inputs produced in China by (partly) foreign-owned establishments, (b) such FIEs may have started producing previously imported inputs in-house, or (c) exports by FIEs may have grown faster than exports by DEs.

After 2007, the DVA share in exports also rose (7.7 percentage points from 2007 to 2012, and 2.9 percentage points from 2012 to 2017, as compared to 3.8 percentage points from 2002 to 2007). In contrast to the first sub-period, however, it was now accompanied by a similar, substantial rise of the national income share (from 51.3% in 2007 to 58.7% in 2012 to 62.8% in 2017). Whereas in the first sub-period more than 80% of the gains in DVA went to capital owners abroad, this was less than 5% in the second sub-period. After 2012, foreign income in exports even decreased. This fundamental difference between the three sub-periods is also clearly reflected in the evolution of the national income to DVA in exports ratio, which declined considerably over 2002–2007 but rebounded after 2007. This result suggests that previously imported intermediate inputs were substituted by products from Chinese firms and/or were produced in-house by such firms. The mirror image of the changes in national income shares in exports is given by the foreign contents

<sup>17</sup> The statistics on DEs and FIEs only cover enterprises with annual sales of 5 million RMB or above. We use the foreign-owned capital shares in these large enterprises as proxies for those of all enterprises here. We use data from *China Census Economic Yearbook 2004* (NBS, 2006) to conduct the estimations for services industries for 2002, and use the *China Census Economic Yearbook 2008* (NBS, 2010) for the estimations for 2007. Since data for paid-in capital are not available in 2012 and 2017, we use data for registered capital to estimate the foreign capital share in FIEs for service industries. This has only a minor impact on our empirical results, for two reasons. First, the data show that paid-in capital and registered capital are quite similar for manufacturing. Second, service sectors only have a small share of the exports.

<sup>18</sup> To see the difference between the paid-in capital data and the registered capital data, we compare them for the manufacturing industry. In the four target years, the foreign-owned capital shares in FIEs are 72.7%, 77.3%, 73.1% and 68.0% for paid-in capital, and 73.2%, 79.5%, 80.7% and 78.2% for registered capital. Agriculture and construction only have a very small share of Chinese total exports (1.2% in 2012), implying that our approximation has little effect on the results.

<sup>19</sup> This indicator is called VAX-D in the taxonomy of value added in exports indicators proposed by Los and Timmer (2018).

<sup>20</sup> Duan et al. (2012) arrived at a 0.6 percentage point lower estimate for the national income share in exports for 2007. We argue that our result reported here is slightly more accurate (see footnote 7).



**Table 1**  
Value composition of exports (2002–2017), in %.

		DVA	National income	National income to DVA ratio	Foreign income	Import content	Foreign content
		(1)	(2)	(3) = (2)/(1)	(4)	(5)	(6) = (4) + (5)
2002	Total exports	55.4	50.6	91.3	4.8	44.6	49.4
	Processing exports	30.6	26.1	85.3	4.5	69.4	73.9
	Ordinary exports	78.5	73.2	93.2	5.3	21.5	26.8
	Domestic production	93.2	91.8	98.5	1.4	6.8	8.2
2007	Total exports	59.2	51.3	86.7	7.9	40.8	48.7
	Processing exports	36.6	29.4	80.3	7.2	63.4	70.6
	Ordinary exports	78.1	69.7	89.2	8.4	21.9	30.3
	Domestic production	88.3	85.0	96.3	3.3	11.7	15.0
2012	Total exports	66.9	58.7	87.8	8.2	33.1	41.3
	Processing exports	39.6	35.7	90.3	3.9	60.4	64.3
	Ordinary exports	84.7	73.7	87.0	11.0	15.3	26.3
	Domestic production	87.3	83.8	96.0	3.5	12.7	16.2
2017	Total exports	69.8	62.8	90.0	7.0	30.2	37.2
	Processing exports	31.9	27.9	87.5	4.0	68.1	72.1
	Ordinary exports	84.1	76.0	90.4	8.1	15.9	24.0
	Domestic production	90.1	88.1	97.8	2.0	9.9	11.9

Note: Values for domestic production relate to the composition of final output for domestic use (rather than exports) and have been included for reference only. Values for ordinary exports and other relate to the exports of this type of subindustries.

of exports (see column 6 in Table 1). Over the decade considered, the role of foreign firms in the value chains of Chinese exports has declined considerably, by as much as about 12 percentage points.

Secondly, we find that the observed trends are different for exports from the two types of exporting subindustries, though both have increased during 2002 to 2012. The national income share of ordinary exports firstly slightly declined from 73.2% in 2002 to 69.7% in 2007, but then kept increasing to 76.0% in 2017. This share was much higher than for processing exports (but still lower than the national income share in the final output of domestic production subindustries), 76.0% vs. 27.9% in 2017. For processing exports, however, the national income share grew rapidly from 26.1% in 2002 to 35.7% in 2012, but then declined to 27.9% in 2017.

In Section 5, we will dig deeper into the sources of these changes. Before turning to that, we first study whether the trends revealed in Table 1 for the aggregate Chinese economy were trends that can be observed across the board, or are the reflection of marked changes in the value chains of a limited number of exported products.

#### 4.2. National income in exports by specific industries

Table 2 presents results for total exports by a selected number of industries and by a few aggregates of industries.<sup>21</sup> The results reveal that Chinese national income as a share of the export value has increased for all industries over the decade spanned by 2002 and 2017. Despite this common pattern, the magnitudes of these shares still varies considerably, even if only major exporting industries are considered. In exports of electronics equipment, the national income share was still lower than 40% in 2017, despite a rapid increase from a share below 20% in 2002.<sup>22</sup> At the other end of the spectrum, about four fifths of the value of exported textiles and clothing products consisted of value added that contributed to national income.

We further aggregate the industries into several categories, including low-tech manufacturing industries (6–11, 13–15, 21), high-tech manufacturing industries (16–20), and energy and materials industries (2–5, 11, 22–24).<sup>23</sup> A comparison of the national income share in exports by the low-tech manufacturing industries aggregate and the high-tech manufacturing industries tells an interesting story. Chinese owners and workers captured a relatively large share of the export value of the low-tech manufacturing industries in 2002 already (57.9%), while the corresponding share for high-tech manufacturing industries was much lower at the time (only 29.2%). After 2007, however, the national income share in high-tech exports rose faster than for low-tech manufacturing products. This convergence confirms the impression that Chinese firms have managed to become more competitive within value chains for sophisticated final products. Still, Timmer, Miroudot, and de Vries (2019) find that the wide-spread notion that China is mainly active in 'low value added' activities in global value chains of 'high-end' products is still accurate. The national income to DVA ratios in exports for the low-tech manufacturing industries aggregate and the high-tech manufacturing industries aggregate suggest that changes in the

<sup>21</sup> Table 2 lists results for selected industries of specific interest, full results are given in Appendix D.

<sup>22</sup> In their seminal case study for iPods exported in 2005, Dedrick, Kraemer, and Linden (2010) estimated a Chinese national income share smaller than 4%.

<sup>23</sup> We defined high-tech and low-tech manufacturing industries according to the CEPII-CHELEM database. It classifies the sectors into four categories based on their Research and Development intensities: High-technology products, Medium-high-technology products, Medium-low-technology products, and Low-technology products. The first two categories are attributed to our high-tech industries, while the last two are belong to our low-tech industries.

**Table 2**  
National income shares in exports (2002–2017), selected industries, in %.

Industry	National income in exports				National income to domestic value added (DVA) ratio				Share of national income generated by all exports			
	2002	2007	2012	2017	2002	2007	2012	2017	2002	2007	2012	2017
7. Textiles	64.4	72.7	75.0	81.0	95.9	93.4	93.0	94.7	11.2	11.7	5.0	4.8
8. Clothes	56.7	66.5	73.5	80.3	94.1	92.6	92.0	95.0	10.1	7.9	9.8	9.7
12. Chemicals	49.4	38.9	57.4	58.2	89.8	83.3	87.4	90.0	6.9	5.5	7.3	6.8
16. Machinery	48.3	50.5	56.9	64.5	91.1	86.0	89.4	92.3	4.0	5.6	7.5	7.8
18. Electrical machinery	36.3	39.8	47.2	61.9	90.2	84.5	86.9	93.8	4.7	5.5	6.3	8.1
19. Electronic equipment	18.4	31.3	38.8	38.0	80.4	80.9	90.9	88.7	5.8	14.3	14.4	14.0
27. Trade	68.0	71.6	74.0	78.1	94.9	77.3	77.1	80.6	11.1	6.2	10.7	10.2
30. Other services	66.1	69.2	70.6	76.3	86.7	79.5	77.8	82.5	8.7	5.6	5.6	5.4
Energy and Materials	61.4	44.1	51.1	78.0	91.2	89.5	87.8	93.8	3.0	1.5	0.8	1.0
High-tech	29.2	37.2	45.9	49.1	86.1	83.6	89.9	90.5	19.5	31.6	33.6	34.1
Low-tech	57.9	62.6	67.6	73.7	93.4	90.8	91.4	93.5	39.5	41.5	34.4	35.1
Aggregate economy	50.6	51.3	58.7	62.8	91.3	86.7	87.8	90.0	100.0	100.0	100.0	100.0

Note: Exports of wholesale and retail trade include trade margins of exported products; exports of transportation include transportation margins for merchandise exports. Results relate to total exports, aggregated over processing exports and ordinary exports sub-industries.

importance of foreign income relative to total income have played a minor role in this convergence: the gap between the national income to DVA ratios of both aggregates narrowed over time, but it was relatively modest in 2002 already.<sup>24</sup> High-tech manufacturing exports require considerably less imports than before, and our results do not provide reason to believe that this improvement has only been attained by foreign-owned firms. This substitution process was much weaker in low-tech manufacturing industries.

However, from 2002 to 2012, four out of 30 industries experienced changes causing a decline of national income shares in exports in the analyzed decade (see Appendix D). These are mainly clustered in what we label energy and materials industries. The national income share in exports of the aggregate of these industries (2–5, 11, 22–24) decreased by 10.3 percentage points. The national income to DVA ratio for this industry aggregate did not change very much over time (see the second set of columns in Table 2), which implies that China's energy and materials exports became increasingly dependent on imported inputs (in particular between 2002 and 2007). We can think of two potential causes. One relates to changes in relative prices, rather than to changes in quantities. The price of crude oil (an important imported input for these industries) increased considerably in this period. The other potential cause is the energy sector liberalization that took place in the early 2000s (Bas & Causa, 2013). Besides private firms, foreign investors were encouraged to get involved in this sector. This exerted a downward pressure on the DVA in exports since FIEs usually use more imported inputs in their production processes than DEs.

The rightmost panel of Table 2 shows the shares of exports by industries in all national income induced by exports. Not surprisingly, the labor-intensive industries aggregate has become less important as a generator of GNI via its exports (its share went down by 7.6 percentage points). Over the same period, the machinery aggregate became responsible for an increasing share of China's national income attributable to exports: its share went up from less than 20% in 2002 to more than a third in 2017. This increase mainly took place in the 2002–2007 period, which is the period in which value chains for various types of machinery became internationally fragmented (see Los, Timmer, & de Vries, 2015a).

#### 4.3. Sensitivity analyses

A major concern regarding Chinese FDI flows data is that part of these might reflect so-called “round-tripping”. This phenomenon relates to capital invested by Chinese investors in the form of FDI through special-purpose entities outside Mainland China, primarily in order to take advantage of preferential fiscal incentives offered to foreign investors (Wei, 2005). Since this capital originates from Chinese firms, reported FDI flows into China are inflated. Therefore, we use the estimates of the magnitude of round-tripping FDI in existing literature (Han, Gan, Hu, & Li, 2012; Xiao, 2004) to calculate the returns of the round-tripped Chinese investments. Then, we add these returns to Chinese GNI and deduct them from the foreign income to investigate the sensitivity of the results presented in the previous subsection. The detailed calculation process are shown in Appendix E. Table 3 presents the empirical results. It turns out our main findings are hardly influenced. The broad tendencies found in the baseline estimation are also found if we correct for the round-tripping investments.

The round-tripping phenomenon is not limited to investment flows. China's exports contain a considerable volume of products that are first exported and then returned to Mainland China for the purpose of currency arbitrage or tax credits receipts (Chao, Chou, & Yu, 2001). This round-tripping of imports does not affect China's trade balance, because it is included both in total exports and in total imports. It might influence the national income share in exports, however, since it may affect the compositions of imported inputs and of exports. We assess the sensitivity of the results reported in Table 1 to stripping the official imports and exports figures from round-tripped imports. The main results are shown in Table 4, while the detailed calculation process is shown in Appendix E. It shows that our

<sup>24</sup> A lot of heterogeneity is hidden in the aggregates. Within the machinery aggregate, for instance, the share of national income in DVA has increased considerably for electronics exports, while it declined for exports of several other types of machinery.

**Table 3**  
National income shares in exports adjusted for round-tripping of FDI (%).

	Baseline scenario (All years: 0%)		Scenario 1: (02, 07, 12 and 17: 25%)		Scenario 2: (02: 25%; 07: 20%; 12: 15%; 17:10%)		Scenario 3: (02: 33.9%; 07,12 and 17: 15.5%)	
	National income	Foreign income	National income	Foreign income	National income	Foreign income	National income	Foreign income
2002	50.6	4.8	51.8	3.6	51.8	3.6	52.2	3.2
2007	51.3	7.9	53.3	5.9	52.9	6.3	52.5	6.7
2012	58.7	8.2	60.8	6.2	59.9	7.0	60.0	6.9
2017	62.8	7.0	64.6	5.3	63.5	6.3	63.9	5.9
Change, 2002 to 2007	0.7	3.1	1.5	2.3	1.1	2.7	0.3	3.5
Change, 2007 to 2012	7.4	0.3	7.5	0.3	7.0	0.7	7.5	0.2
Change, 2012 to 2017	4.1	-1.2	3.8	-1.0	3.6	-0.7	3.9	-1.0

Note: In scenario 1, we consider the situation that round-tripped investment accounted for a quarter of China's total foreign capital in all four years. In scenario 2, the proportion of round-tripped capital in official FDI figures decreased to 20% in 2007 and 15% in 2012. In scenario 3, we adopt the estimates by Xiao (2004) and Han et al. (2012) and assume shares of 33.9% in 2002, and 15.5% in 2007 and 2012.

**Table 4**  
National income shares in exports adjusted for round-tripping of imports (%).

	Baseline Scenario		Scenario 1		Scenario 2	
	National income	Foreign income	National income	Foreign income	National income	Foreign income
2002	50.6	4.8	52.6	4.6	53.8	4.7
2007	51.3	7.9	53.5	8.1	53.8	8.0
2012	58.7	8.2	59.9	8.2	60.1	8.3
2017	62.8	7.0	64.8	7.1	62.9	7.0
Change, 2002 to 2007	0.7	3.1	0.9	3.5	0.0	3.3
Change, 2007 to 2012	7.4	0.3	6.4	0.1	6.3	0.3
Change, 2012 to 2017	4.1	-1.2	4.9	-1.1	2.8	-1.3

Note. Scenario 1: Round-tripped imports proxied by China's re-imports; Scenario 2: Round-tripped imports proxied by China's imports from Hong Kong.

main findings still hold after adjusting for only round-tripping FDI or adjusting for both round-tripping of imports and FDI.

## 5. Results: accounting for changes in the national income share in exports

As discussed in the introduction, the dynamism of the Chinese economy has been reflected in many different types of changes, each of which had impacts on the extent to which its exports contribute to national income. In this section, we will use structural decomposition analysis (SDA, a technique related to shift-share analysis, extended to take input-output relations into account) to analyze which changes contributed most to the tendencies reported in the previous section. Knowing more about the relative importance of the multitude of changes in the recent past is not only interesting in itself, but might also be informative for speculations about what might happen in the future.

### 5.1. Decomposition methodology

We decompose changes in the national income share in exports, over the periods 2002–2007, 2007–2012, and 2012–2017, respectively. With the data available to us, the change in this ratio can be split into contributions of five partial effects<sup>25</sup>:

- Effects of changes in ratios of national income to value added;
- Effects of changes in value added to gross output ratios;
- Effects of changes in domestic intermediate input coefficients, mainly driven by changes in the origin of intermediate inputs;
- Effects of changes in the relative importance of export types (processing exports vs. ordinary exports);
- Effects of changes in the industry composition of exports;

For clarity, we first re-formulate the national income share in exports by combining Eqs. (2) and (3):

<sup>25</sup> The full mathematical details of the decomposition are provided in Appendix F.

$$n = \mathbf{w}^n (\mathbf{I}_{3m} - \mathbf{A})^{-1} \bar{\mathbf{e}} \tag{4}$$

in which the  $3m \times 1$  vector  $\bar{\mathbf{e}} = \mathbf{e}(\mathbf{u}'\mathbf{e})'$  measures the export composition, capturing the share of each commodity and export type in total exports.  $\mathbf{u}$  denotes the summation vector  $\mathbf{u} = (1, \dots, 1)'$ , with the prime indicating transposition. If the vector  $\mathbf{d}$  contains the ratios of national income in value added (the NIVA ratios, hereafter), the national income coefficients vector can be expressed as:  $\mathbf{w}^n = \mathbf{d} \odot \mathbf{w}$ , with the Hadamard product  $\odot$  indicating cell-by-cell multiplication.

Next, we further decompose  $\bar{\mathbf{e}}$  into the shares (at the product level) accounted for by the two trade types ( $\bar{\mathbf{t}}$ ) and the commodity composition of the exports ( $\bar{\mathbf{q}}$ ). That is,  $\bar{\mathbf{e}} = \bar{\mathbf{t}} \odot \bar{\mathbf{q}}$ . The commodity composition of exports is reflected in  $\bar{\mathbf{q}} = (\mathbf{0} \mathbf{q} \mathbf{q})'$ , with  $q_j = e_j/(\mathbf{u}'\mathbf{e})$ . We indicate the share of processing exports in the total exports of each sector by  $\bar{\mathbf{t}} = (\mathbf{0} \mathbf{t} \mathbf{u} - \mathbf{t})'$ , with  $t_j = (e_j^P)/(e_j^P + e_j^N)$ . The national income share in exports can now be represented as

$$n = (\mathbf{d}' \odot \mathbf{w}')(\mathbf{I} - \mathbf{A})^{-1} (\bar{\mathbf{t}} \odot \bar{\mathbf{q}}) \tag{5}$$

By using the popular polar decomposition approach introduced by [Dietzenbacher and Los \(1998\)](#), the changes in the national income share in exports over time is decomposed into the effect of the five independent determinants mentioned above. Appendix F provides the detailed decomposition procedure.

### 5.2. Decomposition results

[Table 5](#) presents the decomposition results.<sup>26</sup> The contribution of each factor varies across the three sub-periods. The largest part of the growth in the national income share in exports from 2002 to 2012 was due to changes in the domestic input structure ( $\Delta\mathbf{A}$ ). If only this determinant structure would have changed, the national income share would have grown by 10.7 percentage points over the entire 10-year period, which is 1.3 times its actual growth in that period. This positive effect reflects the increasing use of domestically sourced intermediate inputs in the production of exports. Appendix G confirms this: a substantial degree of substitution of imports by domestic inputs was observed from 2002 to 2012. This finding is consistent with the conclusion of [Duan, Dietzenbacher, Jiang, Chen, and Yang \(2018\)](#), which concludes that the substitution of imports by domestic products is the major reason for China's decreasing vertical specialization, and with the microeconomic evidence provided by [Kee and Tang \(2016\)](#). However, after 2012,  $\Delta\mathbf{A}$  has remarkably decreased the national income share due to the substitution of domestic intermediate input by imported products and domestic value added as shown in Appendix G.

Changes in the relative importance of trade types (processing exports and ordinary exports) are also an important positive contributor. From 2002 to 2017, these changes alone led to an increase of the national income share by 9.4 percentage points. The share of processing exports in total exports decreased over time, from 48.0% in 2002, to 45.7% in 2007, 39.5% in 2012, and 27.4% in 2017.<sup>27</sup> As already shown in [Table 1](#), the national income share of processing exports has been much lower than that of ordinary exports.

Between 2002 and 2007, the two positive effects of domestic intermediate input coefficient and trade types were offset by the negative effects of changes in other determinants, including the overall decreasing NIVA ratios, the changes in value added ratios, and a changing commodity composition of exports. The net effect was a modest growth in the national income share in exports. Especially, the export composition led to a 4.4 percentage point decline in the national income share from 2002 to 2007, but to a 1.5 percentage point increase from 2007 to 2012. This resonates well with the analysis in [Section 4.2](#). The export share of machinery products, which generate comparatively low national income, expanded rapidly before the crisis. From 2007 to 2012, however, the export share of services, which have high national income shares, has obviously increased (see Appendix G). From 2012 to 2017, the export composition only slightly changed with increasing share of machinery products, which generated a negative effect on national income share in exports.

<sup>26</sup> Ideally, input-output tables in constant prices should be used in the SDA. However, constructing accurate constant price input-output tables requires considerable price information, including the price deflators of processing exports, non-processing exports, and domestic products at the sector level. Unfortunately, this information is not available. As a result, estimating tables at constant prices would introduce many new biases as the lack of data requires us to make assumptions. As we decompose the changes of national income share in exports, which is a ratio instead of an absolute term, the price deflation is less important. Therefore, we use the IO tables in current prices to conduct the SDA. The implied assumption behind this is that the price deflators are the same across different industries. Following the suggestion of one of the anonymous reviewers, we checked (given our limited data availability) whether this assumption seems reasonable. The idea is that a large part of Chinese GNI consists of labor income. Comparing whether changes in labor income are similar to changes in employment, tells us whether the outcomes are affected by price effects or not. We thus compared the changes in the industry shares in total employment with those in total labor income. Assuming that relative productivity of labor in industries did not change, changes in the employment shares gives information on quantity effects alone, changes in the labor income shares gives information on the quantity and price effects together. We collected the employment data at the industry level for 2007, 2012, and 2017 from the Chinese Labour Statistics Yearbook and Chinese Statistical Yearbook. Note that separate information for D, P, and N is not available. We find that the changes in employment shares and labor income shares are highly correlated. The correlation coefficient is 0.84 for the changes between 2007 and 2012 and 0.91 for the changes from 2012 to 2017. This suggests that our decomposition results provide a reasonable reflection of the quantity effects in the changes in national income shares, even if the price effects could not be separated out.

<sup>27</sup> China's rising labor costs led to a shift of manufacturing activities from China to other Asian countries where wages are lower, such as Vietnam, Bangladesh, and Indonesia. Moreover, the collapse in aggregate expenditure due to the crisis was most prominent for durable goods, see [Bems, Johnson, and Yi \(2012\)](#). China's machinery products, for example, are mainly exported as processing export.

**Table 5**  
Decomposition results of changes in the national income share in exports (%).

	NIVA ratio	Value added ratio	Input structure	Trade types	Export composition	Total
2002–2007	−1.9	−2.0	6.1	2.9	−4.4	0.7
2007–2012	0.7	−0.7	4.6	1.5	1.5	7.5
2012–2017	0.8	2.5	−3.4	5.0	−0.7	4.1

The NIVA ratios were another important determinant causing differences between the three sub-periods. Its levels decreased from 2002 to 2007, but increased from 2007 to 2017 (see Appendix G). The major driver behind this are the changes in the capital income share in value added. The data from the tripartite tables indicate that capital income share in value added (aggregated over industries) rose from 37.3% to 44.2% during 2002–2007, but then fell back to 37.1% in 2012. Since foreign income is contained in capital income only, an increasing capital income share would, *ceteris paribus*, reduce the national income share in exports. From 2012 to 2017, the increasing NIVA ratio is mainly due to the increasing foreign capital share in DEs and FIEs, as well as the increasing output share of FIEs.

## 6. Dependence of China's national income on exports

The final question we address is by how much total exports contributed to China's GNI and how this changed over the period 2000–2017, relative to other final demand categories. It is widely believed that China's exports contributed much to its economic growth (e.g., Lardy, 2007). However, some literature argues that China's GDP dependence on exports is significantly lower than what is implied by conventional indicators, such as the exports-to-GDP ratio (He & Zhang, 2010; Pei et al., 2012). These differences in findings are strongly related to the limited DVA generated per unit of processing exports. We expect that the dependence of China's GNI on exports is even lower, in view of the strong presence of foreign-owned firms in exporting activities (and processing exports in particular).

Table 6 documents the dependence of China's GNI and GDP on the four categories of final demand, i.e. consumption, capital formation, processing exports, and ordinary exports. The rows 'share in final demand' present the share of each category in total final demand, while the rows 'GNI dependence' and 'GDP dependence' show the share of GNI and GDP induced by each of the final demand categories.<sup>28</sup>

As expected, China's GNI has been less dependent on exports than its GDP. Processing exports, which accounted for 10.1% of final demand in 2002, only contributed 3.3% of GNI in that year.<sup>29</sup> The relative contribution of exports to GNI increased substantially from 2002 to 2007, but decreased considerably after the crisis, most probably due to sluggish growth during the recovery phase in many of China's most important export destinations.

We then investigate the contributions of growth in each final demand category to Chinese GDP and GNI growth in each sub-period. To do this, we first calculate the national income and DVA induced by each final demand in each year (Eqs. (1)–(3)). Then we deflate the induced national income and DVA as well as the overall GNI and GDP in 2007, 2012, and 2017 into values in 2002 price, using the GDP deflator. Finally, the contributions are computed as the ratio of changes in national income (DVA) induced by each final demand category to the overall changes in Chinese GNI (GDP). The results are depicted in the last panel of Table 6. Exports have contributed 32.4% of GNI growth and 34.8% of GDP growth from 2002 to 2007. This contribution was mainly ascribed to the rapid growth in export volume. However, these contributions dropped to 11.9% for GNI growth and 12.4% for GDP growth in 2007–2012 and to 9.8% for GNI growth and 10.2% for GDP growth in 2012–2017, due to the stagnation of the exports after the 2008 financial crisis. Processing exports even contributed negatively to Chinese GNI and GDP growth in 2012–2017, due to the decline of its volumes as well as the drop in its DVA share and national income share. The continued sluggish growth in Europe and the United States suggests that to achieve sustainable economic growth, the Chinese government might want to devote more attention to improving the national income share in exports rather than only relying on the volume growth of exports (besides, of course, its efforts to achieve a healthy balance between fostering export growth and growth of domestic consumption, see e.g., Los, Timmer, & de Vries, 2015b).

## 7. Conclusions

This paper presents a new input-output accounting method to assess the extent to which China's widely discussed exports expansion implied growth of its national income. A yuan of exports does not imply a yuan of national income, due to two issues. First, the value of exports incorporates not only Chinese domestic value added (DVA), but also the value of the imports directly and indirectly needed to produce them. Second, Chinese value added includes capital income, part of which accrues to foreign owners. Both issues are more prominent for China than for many other countries, given that its remarkable export performance was fueled by an inflow of (partly)

<sup>28</sup> The results have been obtained using Eqs. (1)–(3). The GNI figures in this section only relate to China's national income generated by activities in China itself, excluding national income derived from activities abroad.

<sup>29</sup> Our approach is an accounting approach. A full-blown economic model might include positive feedback effects from exports to consumption and capital formation, through exports-induced household income and reinvestments of retained corporate profits. A long-run perspective would also include the positive effects of knowledge spillovers from the activities of foreign-owned enterprises to domestic enterprises.

**Table 6**  
Dependence of China's GNI and GDP on final demand categories (%).

		Consumption	Capital formation	Processing exports	Ordinary exports	Aggregate
2002	Share in final demand	48.4	30.8	10.1	10.8	100.0
	GNI dependence	55.1	31.5	3.3	9.9	99.8
	GDP dependence	54.6	31.1	3.7	10.4	99.8
2007	Share in final demand	38.2	32.3	13.5	16.0	100.0
	GNI dependence	44.8	33.4	5.5	15.4	99.1
	GDP dependence	43.7	32.8	6.4	16.3	99.1
2012	Share in final demand	41.3	36.9	8.6	13.2	100.0
	GNI dependence	45.3	38.3	3.8	12.2	99.6
	GDP dependence	44.6	37.9	4.0	13.2	99.7
2017	Share in final demand	45.3	37.0	4.9	12.9	100.0
	GNI dependence	48.4	38.4	1.6	11.6	100.0
	GDP dependence	47.9	37.9	1.8	12.4	100.0
2002–2007	GNI growth	29.1	36.4	8.8	23.6	98.0
	GDP growth	28.4	35.0	10.2	24.6	98.2
2007–2012	GNI growth	45.8	43.0	2.3	9.1	100.2
	GDP growth	45.5	42.8	1.7	10.2	100.1
2012–2017	GNI growth	52.1	38.5	−1.1	10.9	100.4
	GDP growth	52.2	38.1	−1.1	11.3	100.5

Note: GDP data in IO tables are slightly different from those in the *Annual China Statistical Yearbook*. GDP shares in this table relate to GDP figures in IO tables. The GNI shares are based on GNI generated inside China, which is different from GNI figure as published by the NBS (which includes earnings generated by Chinese activities abroad). The shares in some rows do not add up not 100% due to the 'error column' in Chinese IO tables, which NBS uses to balance them.

foreign-owned firms and the introduction of processing export zones, the activities in which relied strongly on imported parts and components.

We study the period 2002–2017, which largely coincides with the rise of China as the 'Factory of the World'. The availability of the required data not just for these two years but also for 2007 and 2012, allows us to consider three subperiods. We find that national income and DVA induced by exports experienced completely different dynamics before and after the global crisis. DVA in exports increased considerably in both subperiods. Between 2002 and 2007, this was mainly a reflection of increases in the profits of foreign investors, while the share of national income grew substantially after 2007.

Our paper extends the work of [Duan et al. \(2012\)](#) and [Ma et al. \(2015\)](#) to a longitudinal context. Compared to their work, this paper considers the *changes* in exports and their effects on GDP and GNI, rather than their levels at a specific point in time. We find that the dependence of Chinese exports on other countries changed between 2002 and 2007 from depending on imported inputs to a dependence on domestic inputs produced using foreign capital. After 2007 the dependence declined even further, but in this period increasing shares of domestic inputs were produced in domestic enterprises with very limited foreign capital.

To study the relative importance of potential determinants of these different patterns, we relied on structural decomposition analysis, which is an accounting method that can be applied if two or more comparable input-output tables are available. From 2002 to 2012, the decade-long rise of DVA in exports has mainly been due to changes in the requirements of domestic intermediate inputs in the production processes of exports *within* processing exports and ordinary exports subindustries. Imported materials, parts and components were substituted by domestic inputs, which is in line with the microeconomic evidence suggesting increasing Chinese production capabilities as reported by [Kee and Tang \(2016\)](#). From 2012 to 2017, the increasing value added ratio played a larger role in the increasing DVA in exports. The effects were reinforced by a continued *between* effect. Processing exports became increasingly less prominent in China's exports bundle from 2002 to 2017. This matters because per yuan, ordinary exports contain much more DVA than processing exports.

The very slow growth of national income in exports in the early phase of China's emergence as a hub in the global economy was mainly due to an unfavorable change in the mix of its export composition (away from products inducing much national income, to products relying mainly on imported inputs and activities of foreign-owned enterprises). Reductions in value added per unit of output and the ratio between national income and value added (related to increased shares of partially foreign-owned capital income in DVA) added to this. After 2007, the tendencies for the export composition and the national income per unit of value added were reversed, and the downward pressure exerted by falling value added to gross output ratios became much weaker. In sum, we find that China's dependence on foreign countries in producing its exports initially shifted from a reliance on foreign products to a dependence on foreign capital. Only after 2007, a yuan of exports started to yield increasing contributions to national income. The analytical framework proposed in this paper might be used to find out whether these stages in a process of export-led growth can also be observed for other countries, such as Mexico and Vietnam.

Despite these results, the relative contribution of exports to Chinese GNI increased substantially from 2002 to 2007, but fell seriously after 2007. This is due to the extraordinary growth of its export volume before the crisis and the stagnation of the exports afterwards. Given the non-sustainable nature of rapid export expansion, the Chinese government could, besides stimulating consumption by Chinese households, focus on having Chinese firms moving towards more value-adding activities in global value chains, to achieve steady long-run economic growth. The wave of foreign direct investment could well bring such long-run benefits. As observed at an early stage by [Zhang and Song \(2001\)](#), [Zhang \(2002\)](#) and [Gao \(2005\)](#), among others, China might well benefit from foreign profits

when they are reinvested, further contributing to the technological capabilities and productivity growth of domestic firms.

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**Appendix A. Estimation of national capital income**

To explain our estimation process of national capital income in more detail, we start at the industry level and begin with the introduction of some variables. We denote the proportions of foreign-owned capital in the capital stocks of DEs (domestic enterprises) and FIEs (foreign-invested enterprises) in industry  $j$  by  $k_{dj}$  and  $k_{fj}$  respectively. The capital income-output ratio of DEs and FIEs in industry  $j$  are labeled  $r_{dj}$  and  $r_{fj}$ , respectively.

Taking processing exports as an example, the estimation process is as follows. Denote  $s_j^p$  as the output share of FIEs in processing exports. Firstly, the processing exports of industry  $j$  are divided into output of FIEs and output of DEs, that is,  $x_j^p s_j^p$  and  $x_j^p (1 - s_j^p)$  respectively. We assume that every unit of capital in a given industry receives the same compensation, regardless of the ownership of that unit. Accordingly, the total capital income in DEs is  $x_j^p (1 - s_j^p) r_{dj}$ , of which  $x_j^p (1 - s_j^p) r_{dj} k_{dj}$  is foreign-owned capital income. Similarly, the total capital income in FIEs is  $x_j^p s_j^p r_{fj}$ , of which  $x_j^p s_j^p r_{fj} k_{fj}$  is the foreign-owned capital income. Then the sum of foreign-owned capital income in DEs and FIEs yields the total foreign-owned capital income in processing exports:

$$ci_j^{pf} = x_j^p \left( 1 - s_j^p \right) r_{dj} k_{dj} + x_j^p s_j^p r_{fj} k_{fj} \tag{A.1}$$

The total capital income in processing exports is given by the sum of capital income in FIEs and DEs:

$$ci_j^p = x_j^p \left( 1 - s_j^p \right) r_{dj} + x_j^p s_j^p r_{fj} \tag{A.2}$$

The share of foreign-owned capital income in total capital income in the processing exports can then be obtained as the ratio between Eqs. (A.1) and (A.2). Defining  $r_j = r_{fj}/r_{dj}$  as the ratio of capital income-output ratio of FIEs to that of DEs, measuring the difference in capital requirements per unit of output between the two different firm types within processing exports industry  $j$ , and dividing numerator and denominator by  $r_{dj}$  we obtain:

$$p_j^p = \frac{ci_j^{pf}}{ci_j^p} = \frac{\left( 1 - s_j^p \right) k_{dj} + s_j^p r_j k_{fj}}{1 - s_j^p + s_j^p r_j} \tag{A.3}$$

Next, denote  $c_j^p$  as the capital income share of processing exports  $j$ , which is derived from the tripartite tables and defined as the aggregate proportion of fixed asset depreciation and operating surplus in all value added  $v_j^p$  (which is, given that all output of processing exports subindustries must be sold abroad, equal to value added due to exports). The adjusted foreign-owned capital income of processing exports  $j$  can then be expressed as

$$v_j^{fp} = c_j^p v_j^p p_j^p = c_j^p v_j^p \frac{\left( 1 - s_j^p \right) k_{dj} + s_j^p r_j k_{fj}}{1 - s_j^p + s_j^p r_j} \tag{A.4}$$

Given that we assume that all taxes and labor income contribute to national income, Eq. (A.4) is the foreign income induced by processing exports subindustry  $j$ .<sup>30</sup> Deducting the foreign income from the value added generates the national income. Hence, the foreign income coefficient and national income coefficient of processing exports  $j$  are

$$w_j^{fp} = \frac{v_j^{fp}}{x_j^p} = c_j^p w_j^p \frac{\left( 1 - s_j^p \right) k_{dj} + s_j^p r_j k_{fj}}{1 - s_j^p + s_j^p r_j} \tag{A.5}$$

and

$$w_j^{np} = \frac{v_j^{np}}{x_j^p} = \frac{v_j^p - v_j^{fp}}{x_j^p} = w_j^p - c_j^p w_j^p \frac{\left( 1 - s_j^p \right) k_{dj} + s_j^p r_j k_{fj}}{1 - s_j^p + s_j^p r_j} \tag{A.6}$$

Turning to matrix notation to generalize the results for processing exports subindustry  $j$  to all subindustries engaged in processing exports, the diagonal elements of the matrix in the left hand side of eq. (A.7) give the national income coefficients of processing exports subindustries

<sup>30</sup> If the capital income-output ratios are equal for FIEs and DEs in all industries ( $r_j = 1$ ), equation (A.4) yields the formula adopted by Duan et al. (2012) to estimate foreign-owned capital income, i.e.,  $v_j^{fp} = c_j^p v_j^p (k_{dj} - s_j^p k_{dj} + s_j^p k_{fj})$ .

$$\widehat{\mathbf{w}}^{nP} = \widehat{\mathbf{w}}^P - \widehat{\mathbf{c}}^P \widehat{\mathbf{w}}^P \left( \widehat{\mathbf{k}}_d - \widehat{\mathbf{s}}^P \widehat{\mathbf{k}}_d + \widehat{\mathbf{s}}^P \widehat{\mathbf{r}} \widehat{\mathbf{k}}_f \right) (\mathbf{I}_m - \widehat{\mathbf{s}}^P + \widehat{\mathbf{s}}^P \widehat{\mathbf{r}})^{-1} \tag{A.7}$$

Bold symbols refer to vectors with the corresponding symbols in italics in Eqs. (A.1)–(A.7) as elements:  $\mathbf{c}^P$  is the capital income share vector of processing exports;  $\mathbf{s}^P$  is the vector of FIEs' output share in processing exports;  $\mathbf{k}_d$  refers to the vector of foreign-owned capital share in DEs, indicating the proportion of foreign-owned capital stock in total capital stock of DEs.  $\mathbf{k}_f$  is the vector of foreign-owned capital share in FIEs.  $\mathbf{r}$  shows the capital income-output ratio in FIEs relative to that of DEs. A hat indicates a diagonal matrix of with the elements of one of these vectors on the main diagonal.

By analogy, national income coefficients for subindustries in domestic production and ordinary exports and others can be expressed as:

$$\widehat{\mathbf{w}}^{nD} = \widehat{\mathbf{w}}^D - \widehat{\mathbf{c}}^D \widehat{\mathbf{w}}^D \left( \widehat{\mathbf{k}}_d - \widehat{\mathbf{s}}^D \widehat{\mathbf{k}}_d + \widehat{\mathbf{s}}^D \widehat{\mathbf{r}} \widehat{\mathbf{k}}_f \right) (\mathbf{I}_m - \widehat{\mathbf{s}}^D + \widehat{\mathbf{s}}^D \widehat{\mathbf{r}})^{-1} = \widehat{\mathbf{w}}^D - \widehat{\mathbf{c}}^D \widehat{\mathbf{w}}^D \widehat{\mathbf{k}}_d \tag{A.8}$$

and

$$\widehat{\mathbf{w}}^{nN} = \widehat{\mathbf{w}}^N - \widehat{\mathbf{c}}^N \widehat{\mathbf{w}}^N \left( \widehat{\mathbf{k}}_d - \widehat{\mathbf{s}}^N \widehat{\mathbf{k}}_d + \widehat{\mathbf{s}}^N \widehat{\mathbf{r}} \widehat{\mathbf{k}}_f \right) (\mathbf{I}_m - \widehat{\mathbf{s}}^N + \widehat{\mathbf{s}}^N \widehat{\mathbf{r}})^{-1} \tag{A.9}$$

in which  $\mathbf{c}^D$  and  $\mathbf{c}^N$  represent the capital income shares in domestic production and in ordinary exports and others, respectively.  $\mathbf{s}^D$  and  $\mathbf{s}^N$  denote FIEs' output shares in domestic production and in ordinary exports and others, respectively. As all domestic production subindustries exclusively consist of DEs, we have  $\mathbf{s}^D = \mathbf{0}$ . We can then express the national income coefficients for all the three types of production in one formula. That is,

$$\widehat{\mathbf{w}}^n = \widehat{\mathbf{w}} - \widehat{\mathbf{c}} \widehat{\mathbf{w}} \left( \widehat{\mathbf{k}}_d - \widehat{\mathbf{s}} \widehat{\mathbf{k}}_d + \widehat{\mathbf{s}} \widehat{\mathbf{r}} \widehat{\mathbf{k}}_f \right) (\mathbf{I}_{3m} - \widehat{\mathbf{s}} + \widehat{\mathbf{s}} \widehat{\mathbf{r}})^{-1} \tag{A.10}$$

with  $\mathbf{c} = (\mathbf{c}^D \ \mathbf{c}^P \ \mathbf{c}^N)$ ,  $\mathbf{s} = (\mathbf{0} \ \mathbf{s}^P \ \mathbf{s}^N)$ ,  $\widehat{\mathbf{k}}_d = (\mathbf{k}_d \ \mathbf{k}_d \ \mathbf{k}_d)$ ,  $\widehat{\mathbf{k}}_f = (\mathbf{k}_f \ \mathbf{k}_f \ \mathbf{k}_f)$ , and  $\widehat{\mathbf{r}} = (\mathbf{r} \ \mathbf{r} \ \mathbf{r})$ .

**Appendix B. Industry classification in tripartite input-output tables**

Code	Industry	Industry Code in the NBS Official Input-Output Tables (2002/2007)	Industry Code in the NBS Official Input-Output Tables (2012 and 2017)
1	Agriculture, Forestry, Animal Husbandry & Fishery	1	1
2	Mining and Washing of Coal	2	2
3	Extraction of Petroleum and Natural Gas	3	3
4	Mining of Metal Ores	4	4
5	Mining and Processing of Nonmetal Ores and Other Ores	5	5
6	Manufacture of Foods and Tobacco	6	6
7	Manufacture of Textile	7	7
8	Manufacture of Textile Wearing Apparel, Footwear, Caps, Leather, Fur, Feather (Down) and Its products	8	8
9	Processing of Timbers and Manufacture of Furniture	9	9
10	Papermaking, Printing and Manufacture of Articles for Culture, Education and Sports Activities	10	10
11	Processing of Petroleum, Coking, Processing of Nuclear Fuel	11	11
12	Chemical Industry	12	12
13	Manufacture of Nonmetallic Mineral Products	13	13
14	Smelting and Rolling of Metals	14	14
15	Manufacture of Metal Products	15	15
16	Manufacture of General Purpose and Special Purpose Machinery	16	16,17
17	Manufacture of Transport Equipment	17	18
18	Manufacture of Electrical Machinery and Equipment	18	19
19	Manufacture of Communication Equipment, Computer and Other Electronic Equipment	19	20
20	Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work	20	21
21	Manufacture of Artwork, Other Manufacture	21–22	22–24
22	Production and Supply of Electric Power and Heat Power	23	25
23	Production and Distribution of Gas	24	26
24	Water production and supply	25	27
25	Construction	26	28
26	Traffic, Transport and Storage, Post	27–28	30
27	Wholesale and retail trade	30	29
28	Hotels and Catering Services	31	31

(continued on next page)



(continued)

Code	Industry	Industry Code in the NBS Official Input-Output Tables (2002/2007)	Industry Code in the NBS Official Input-Output Tables (2012 and 2017)
29	Public management and social administration	42	42
30	Other services	29,32-41	32-41

**Appendix C. Data sources**

Variable	Required source data	Sources
Capital income shares in value added (c)	The ratio of capital income to value added	The tripartite tables
Output shares of FIEs (s)	FIEs' output for domestic use Processing exports of FIEs Non-processing exports of FIE	The tripartite tables China's Customs China's Customs
Foreign capital shares in DEs and FIEs ( $k_d$ and $k_f$ )	Paid-in capital for industrial sectors Paid-in capital for service sectors	China Industrial Economy Statistical Yearbook 2003, 2008, 2013, and 2018 China Economic Census Yearbook 2004, 2008
Capital income-output ratios ( $r_d$ and $r_f$ )	Registered capital of FIEs in Agriculture and Construction Output of FIEs and DEs for industrial sectors Depreciation and operating profits in FIEs and DEs for industrial sectors Output, depreciation and operating profits for FIEs and DEs for Construction Operating income, depreciation and operating profits of FIEs and DEs for services Capital income-output ratio for agriculture	China Statistical Yearbook 2003, 2008, 2013, and 2018 China Industrial Economy Statistical Yearbook 2003, 2008, 2013, and 2018 China Industrial Economy Statistical Yearbook 2003, 2008, 2013, and 2018 China Statistical Yearbook 2003, 2008, 2013, and 2018 China Economic Census Yearbook 2004, 2008; China Statistical Yearbook 2013 and 2018; The tripartite tables

**Appendix D. National income shares in total exports (2002–2017) at the industry level, in %**

Industry	National income in exports				National income to DVA ratio (%)				Share in national income generated by all exports			
	2002	2007	2012	2017	2002	2007	2012	2017	2002	2007	2012	2017
1	86.0	91.2	86.3	92.1	96.4	97.0	97.0	96.9	2.6	1.2	0.9	1.0
2	79.4	78.5	84.0	89.5	93.7	91.8	92.6	94.6	0.8	0.3	0.1	0.1
3	69.0	76.0	67.2	73.7	79.9	85.1	78.1	80.9	0.5	0.3	0.5	0.0
4	69.8	69.8	75.6	71.8	94.1	89.4	90.1	91.5	0.1	0.1	0.1	0.0
5	65.3	51.4	75.8	80.2	94.9	88.6	87.3	90.2	0.6	0.2	0.1	0.1
6	72.0	60.8	70.2	72.2	92.8	88.4	90.7	91.9	4.1	2.3	2.5	2.5
7	64.4	72.7	75.0	81.0	95.9	93.4	93.0	94.7	11.2	11.7	5.0	4.8
8	56.7	66.5	73.5	80.3	94.1	92.6	92.0	95.0	10.1	7.9	9.8	9.7
9	58.3	67.3	76.9	75.0	91.7	91.1	93.7	95.4	2.5	3.2	3.4	3.4
10	46.4	49.4	52.1	61.8	88.2	87.8	88.3	91.5	2.9	2.5	3.8	4.2
11	42.3	24.6	6.0	66.9	94.1	91.4	95.8	95.1	0.7	0.5	0.0	0.7
12	49.4	38.9	57.4	58.2	89.8	83.3	87.4	90.0	6.9	5.5	7.3	6.8
13	66.4	68.6	75.7	77.0	93.8	88.3	91.1	90.0	1.8	2.0	2.5	2.1
14	52.7	54.5	62.6	66.1	92.5	90.0	92.2	94.6	1.5	5.5	3.6	3.1
15	48.1	61.2	64.0	72.3	91.5	87.9	91.3	92.6	3.3	4.2	3.4	3.7
16	48.3	50.5	56.9	64.5	91.1	86.0	89.4	92.3	4.0	5.6	7.5	7.8
17	45.4	53.4	59.6	58.2	92.6	89.9	89.9	91.6	1.9	3.4	4.3	3.2
18	36.3	39.8	47.2	61.9	90.2	84.5	86.9	93.8	4.7	5.5	6.3	8.1
19	18.4	31.3	38.8	38.0	80.4	80.9	90.9	88.7	5.8	14.3	14.4	14.0
20	31.9	35.5	45.9	49.4	82.2	85.2	92.5	89.5	3.0	2.7	1.0	1.1
21	52.0	57.7	60.6	75.2	93.3	67.5	78.3	87.8	1.4	1.7	0.4	0.9
22	49.7	65.5	75.8	78.6	85.4	87.2	92.8	91.3	0.0	0.1	0.1	0.1
23	73.4	83.8	69.7	75.3	94.0	90.5	88.6	90.7	0.2	0.0	0.0	0.0
24	71.8	79.2	79.7	84.2	88.8	84.5	86.6	90.1	0.0	0.0	0.0	0.0
25	72.3	65.2	80.8	83.7	95.0	91.2	93.5	95.6	0.5	0.5	0.8	0.7
26	72.1	77.1	73.8	79.5	93.9	95.4	88.2	88.6	7.0	5.9	5.2	6.0
27	68.0	71.6	74.0	78.1	94.9	77.3	77.1	80.6	11.1	6.2	10.7	10.2
28	70.8	75.6	85.3	80.2	93.1	81.8	90.4	84.7	1.6	1.1	0.6	0.4
29	86.7	81.1	89.7	92.7	98.6	98.4	98.0	98.7	0.2	0.1	0.1	0.1
30	66.1	69.2	70.6	76.3	86.7	79.5	77.8	82.5	8.7	5.6	5.6	5.4
Energy and material industries	61.4	44.1	51.1	78.0	91.2	89.5	87.8	93.8	3.0	1.5	0.8	1.0

(continued on next page)

(continued)

Industry	National income in exports				National income to DVA ratio (%)				Share in national income generated by all exports			
	2002	2007	2012	2017	2002	2007	2012	2017	2002	2007	2012	2017
High-tech manufacturing industries	29.2	37.2	45.9	49.1	86.2	83.6	89.9	90.5	17.5	31.6	33.6	34.1
Low-tech manufacturing industries	57.9	62.6	67.6	73.7	93.4	90.8	91.4	93.5	39.5	41.5	34.4	35.1
Total	50.6	51.3	58.7	62.8	91.3	86.7	87.0	90.0	100.0	100.0	100.0	100.0

## Appendix E. The procedure and results in sensitivity analysis

### E.1. Round-tripping of FDI

In the existing literature, estimates of the magnitude of round-tripping FDI vary substantially, which is understandable given that firms use this ‘trick’ to deceive authorities. The most popular estimate is from the World Bank, which suggests that a quarter of China’s total FDI inflows reflect round-tripping (World Bank, 2002).<sup>31</sup> Xiao (2004) is among the few studies providing details about the method and data used, arriving at a share of 33.9% for the 1998–2002 period. Using the same method, Han et al.’s (2012) more recent study focused on FDI from Hong Kong in specific and estimated that about 15.5% of its 1998–2002 FDI into China related to round-tripping. Given the uncertainty about the true magnitude of round-tripping of Chinese FDI, we will assess our results based on three scenarios. In the first of these, we assume that round-tripped investment accounted for a quarter of China’s total foreign capital in 2002, 2007 and 2012. Since Broadman and Sun (1997) and Davies (2012) argue that the relative magnitude of round-tripping of FDI gradually decreased as a result of Chinese policy adjustments, we assume in scenario 2 that the proportion of round-tripped capital in official FDI figures decreased to 20% in 2007 and 15% in 2012.<sup>32</sup> In scenario 3, we adopt the estimates by Xiao (2004) and Han et al. (2012) and assume shares of 33.9% in 2002, and 15.5% in 2007 and 2012. In the absence of both industry-level estimates, we assume that these percentages apply to all industries.

We assume that round-tripped investment generated rates of return identical to those on ‘truly foreign’ capital,<sup>33</sup> which implies that the proportion of income from round-tripped investment in foreign income is the same as the proportion of round-tripped FDI in total FDI. Based on the foreign income figures that we reported in Table 1, we obtain the income in exports, which should not be part of foreign income due to round-tripping of investment. We deduct this income from foreign income and add it to national income. Our adjusted estimates of the national income share in exports are presented in Table 3.

Table 3 shows that the increase in the foreign income was still the most important contributor to the total increase of DVA in exports from 2002 to 2007, also after considering round-tripping of FDI. In contrast, the increase in national income share dominates the increase of DVA share in exports during 2007 to 2012 and 2012 to 2017. Hence, the broad tendencies found in the baseline scenario are also found if we correct for Chinese investments into China via e.g. Hong Kong and Macau.

### E.2. Round-tripping of imports

As the true volume of round-tripping of imports is unknown, we specify two scenarios that should give some insights into the rough magnitudes of the changes in our results. The first scenario uses China’s re-imports data. In these data, re-imports are defined as products exported by China and subsequently imported by China via a third country (or regions like Hong Kong, Macau and Taiwan, or a ‘bonded zone’). In Chinese statistics, these flows are recorded as ‘China–China trade’ (Liu, 2013). Re-imports accounted for 5.1% of China’s total imports in 2002, 9.0% in 2007, 7.9% in 2012, and 7.2% in 2017. These re-imports data provide a lower bound for the volume of round-tripping of imports. In addition, some round-tripped products are imported into China after having acquired formal status as ‘exported to a foreign area’. Given that experts believe that most of China’s round-tripping of exports goes through Hong Kong (Liu, 2013), we consider re-imports plus China’s imports from Hong Kong as an upper bound of the round-tripped trade volume in scenario 2. Imports from Hong Kong accounted for 3.6% of Chinese total imports in 2002, 1.3% in 2007, 1.0% in 2012, and 0.4% in 2017.

We take both the re-imports data and China’s import data from Hong Kong from the UN Comtrade Database, at HS-6 digit level. Using the UN Broad Economic Categories (BEC) classification, we split the imports and re-imports into three categories: for intermediate use, for final consumption, and for investment. Afterwards, these data are further regrouped to match the industry classification used for the tripartite input-output tables, based on an unpublished concordance between HS-6 digit commodities and the IO classification provided by the NBS.

Two adjustments of the tripartite tables are necessary to analyze the consequences of round-tripping of imports.

First, we re-estimate the domestic intermediate coefficients, since the round-tripped imports for intermediate use should be

<sup>31</sup> Other estimates in the literature for the early period considered in this paper range from 10%–15% to 37% (see, e.g. UNCTAD, 2003; Wei, 2005).

<sup>32</sup> These policy adjustments included the elimination of an exemption from customs duties of imported capital equipment and the value added tax for FIEs in 1996 (Broadman and Sun, 1997), tighter reporting standards for special purpose entities established abroad by Chinese companies since 2006, and the abolition of some foreign investment incentives from 2008 (Davies, 2012). These policies significantly decreased the incentives for Chinese investors to invest in the form of FDI.

<sup>33</sup> It also identical to the return rates of national capital, since the national capital and foreign capital have the same return rate in our estimations.

considered as domestic inputs rather than as imported inputs. To this end, we first estimate the intermediate coefficient matrix of round-tripped imports ( $A_r$ ) by assuming proportionality between use of a round-tripped input and total use of this input (domestically sourced and imported). Denote  $\mathbf{m}_r$  as the vector with all round-tripped imports for each of the subindustries, and  $\mathbf{m}_{ri}$  as the vector with round-tripped imports for intermediate use. These round-tripped imports lead to overestimations of China's imports. A round-tripped imported intermediate matrix can be calculated as  $Z_r^M = Z^M(\hat{\mathbf{m}})^{-1}\hat{\mathbf{m}}_{ri}$ , where  $\mathbf{m} = Z^M\mathbf{u}$  and  $Z^M$  is directly taken from the tripartite input-output table (see Fig. 1). As previously mentioned,  $Z_r^M$  should be part of the domestic intermediate inputs matrix, since they are produced by either DEs or FIEs and used in China. Accordingly, we split  $Z_r^M$  into two parts based on a proportionality assumption. The former is formulated as  $Z_r^D = Z^D \oslash (Z^D + Z^N) \oslash Z_r^M$ , and the latter is obtained by residues, i.e.,  $Z_r^N = Z_r^M - Z_r^D$ , where  $Z^D = (Z^{DD} \ Z^{DP} \ Z^{DN})$ ,  $Z^N = (Z^{ND} \ Z^{NP} \ Z^{NN})$ ,  $\oslash$  and  $\oslash$  indicate cell-by-cell (Hadamard) multiplication and cell-by-cell division respectively. Thus, after reclassification of the round-tripped imports, the true domestic coefficient matrix is  $\mathbf{A} + \mathbf{A}_r$ , with  $\mathbf{A}_r =$

$$\begin{pmatrix} Z_r^D \\ \mathbf{0} \\ Z_r^N \end{pmatrix} \hat{\mathbf{x}}^{-1}. \text{ By adding this matrix to the original domestic input coefficients matrix, we obtain the adjusted domestic coefficient}$$

matrix,  $\mathbf{A} + \mathbf{A}_r$ .

Second, we adjust the exports column, since it includes round-tripped imports. Like input-output tables for most countries, the Chinese tables contain exports expressed in free on board (f.o.b.) prices, while imports are expressed in cost, insurance and freight (c.i.f.) prices. The latter include margins for international transport and trade, and are therefore higher. To correct for this, we apply a 10% discount to the value of round-tripped imports to obtain a value of round-tripped exports (denoted as  $\mathbf{e}_r$ ) that can be deducted from the exports column.<sup>34</sup> We then adopt a proportionality assumption to split the round-tripped exports into exports of two regimes: round-tripped processing exports, and round-tripped ordinary exports. They are given by  $\mathbf{e}_r^P = \mathbf{e}^P \oslash (\mathbf{e}^P + \mathbf{e}^N) \oslash 0.9\mathbf{m}_r$  and  $\mathbf{e}_r^N = 0.9\mathbf{m}_r - \mathbf{e}_r^P$ ,

respectively. The true export vector is  $\mathbf{e} - \mathbf{e}_r$ , with  $\mathbf{e}_r = \begin{pmatrix} \mathbf{0} \\ \mathbf{e}_r^P \\ \mathbf{e}_r^N \end{pmatrix}$ . Hence, considering the round-tripping of imports, the national income

in total exports is given by

$$n\hat{i}_r^e = \mathbf{w}'(\mathbf{I}_{3m} - \mathbf{A} - \mathbf{A}_r)^{-1}(\mathbf{e} - \mathbf{e}_r) \tag{E.1}$$

In this equation,  $(\mathbf{e} - \mathbf{e}_r)$  is a vector with  $3m$  elements, which implies that exports by processing trade subindustries and by ordinary exports subindustries are both taken into account. The results obtained using Eq. (E.1) are presented in Table 4. The numbers for both scenarios reveal that the national income share in exports increase somewhat if round-tripping of imports is proxied by either one of our methods, but that the results do not change in a qualitative sense. While growth in foreign income accounted for most of the increase of DVA in exports from 2002 to 2007, the national income share increased much faster afterwards. Table E then list the national income shares in exports if we adjusted for both round-tripping of imports and FDI. Our main findings are still robust.

**Table E**

National income share in exports adjusted for both round-tripping of imports and FDI, in %.

	Baseline Scenario		Scenario 1		Scenario 2	
	National income	Foreign income	National income	Foreign income	National income	Foreign income
2002	50.6	4.8	53.8	3.4	55.0	3.5
2007	51.3	7.9	55.5	6.1	55.8	6.0
2012	58.7	8.2	62.0	6.2	62.2	6.3
2017	62.8	7.0	66.6	5.3	64.7	5.3
Change, 2002 to 2007	0.7	3.1	1.7	2.7	0.8	2.5
Change, 2007 to 2012	7.4	0.3	6.5	0.0	6.4	0.2
Change, 2012 to 2017	4.1	-1.2	4.6	-0.9	2.5	-1.0

Note: Scenario 1: Round-tripped imports proxied by China's re-imports; Scenario 2: Round-tripped imports proxied by China's imports from Hong Kong. In both sensoria, the proportion of round-tripped capital in official FDI figures are all 25% in all four years.

**Appendix F. Decomposition on the national income share**

In Section 5, we split the total change in the national income share in exports over time into parts attributable to changes in specific determinants. The results of such a structural decomposition analysis can be affected considerably by the weights used, in particular when changes over longer periods of time are considered (Dietzenbacher & Los, 1998, 2013). The weighting approach used in Section 5 is in line with the widely adopted recommendations of the Dietzenbacher and Los paper.

<sup>34</sup> Fung and Lau (2003) applied a 10% discount to convert c.i.f. prices to f.o.b. prices. We also assessed the sensitivity of our results by adopting discount rates ranging from 5% to 30%, but did not find economically significant differences.

We use subscript 0 to indicate the variables in the initial year, and 1 for that in final year. We use the symbol  $\Delta$  to denote the change in a variable between those two years, e.g.  $\Delta n = n_1 - n_0$ . The basic decomposition then reads as

$$\Delta n = (\mathbf{d}'_1 \odot \mathbf{w}'_1)(\mathbf{I} - \mathbf{A}_1)^{-1} \left( \bar{\mathbf{t}}_1 \odot \bar{\mathbf{q}}_1 \right) - (\mathbf{d}'_0 \odot \mathbf{w}'_0)(\mathbf{I} - \mathbf{A}_0)^{-1} \left( \bar{\mathbf{t}}_0 \odot \bar{\mathbf{q}}_0 \right)$$

$$= (\Delta \mathbf{d}' \odot \mathbf{w}'_1)(\mathbf{I} - \mathbf{A}_1)^{-1} \left( \bar{\mathbf{t}}_1 \odot \bar{\mathbf{q}}_1 \right) \tag{F.1a}$$

$$+ (\mathbf{d}'_0 \odot \Delta \mathbf{w}')(\mathbf{I} - \mathbf{A}_1)^{-1} \left( \bar{\mathbf{t}}_1 \odot \bar{\mathbf{q}}_1 \right) \tag{F.1b}$$

$$+ (\mathbf{d}'_0 \odot \mathbf{w}'_0)[(\mathbf{I} - \mathbf{A}_1)^{-1} - (\mathbf{I} - \mathbf{A}_0)^{-1}] \left( \bar{\mathbf{t}}_1 \odot \bar{\mathbf{q}}_1 \right) \tag{F.1c}$$

$$+ (\mathbf{d}'_0 \odot \mathbf{w}'_0)(\mathbf{I} - \mathbf{A}_0)^{-1} \left( \Delta \bar{\mathbf{t}} \odot \bar{\mathbf{q}}_1 \right) \tag{F.1d}$$

$$+ (\mathbf{d}'_0 \odot \mathbf{w}'_0)(\mathbf{I} - \mathbf{A}_0)^{-1} \left( \bar{\mathbf{t}}_0 \odot \Delta \bar{\mathbf{q}} \right) \tag{F.1e}$$

The mirror image is given by

$$\Delta n = (\mathbf{d}'_1 \odot \mathbf{w}'_1)(\mathbf{I} - \mathbf{A}_1)^{-1} \left( \bar{\mathbf{t}}_1 \odot \bar{\mathbf{q}}_1 \right) - (\mathbf{d}'_0 \odot \mathbf{w}'_0)(\mathbf{I} - \mathbf{A}_0)^{-1} \left( \bar{\mathbf{t}}_0 \odot \bar{\mathbf{q}}_0 \right)$$

$$= (\Delta \mathbf{d}' \odot \mathbf{w}'_0)(\mathbf{I} - \mathbf{A}_0)^{-1} \left( \bar{\mathbf{t}}_0 \odot \bar{\mathbf{q}}_0 \right) \tag{F.2a}$$

$$+ (\mathbf{d}'_1 \odot \Delta \mathbf{w}')(\mathbf{I} - \mathbf{A}_0)^{-1} \left( \bar{\mathbf{t}}_0 \odot \bar{\mathbf{q}}_0 \right) \tag{F.2b}$$

$$+ (\mathbf{d}'_1 \odot \mathbf{w}'_1)[(\mathbf{I} - \mathbf{A}_1)^{-1} - (\mathbf{I} - \mathbf{A}_0)^{-1}] \left( \bar{\mathbf{t}}_0 \odot \bar{\mathbf{q}}_0 \right) \tag{F.2c}$$

$$+ (\mathbf{d}'_1 \odot \mathbf{w}'_1)(\mathbf{I} - \mathbf{A}_1)^{-1} \left( \Delta \bar{\mathbf{t}} \odot \bar{\mathbf{q}}_0 \right) \tag{F.2d}$$

$$+ (\mathbf{d}'_1 \odot \mathbf{w}'_1)(\mathbf{I} - \mathbf{A}_1)^{-1} \left( \bar{\mathbf{t}}_1 \odot \Delta \bar{\mathbf{q}} \right) \tag{F.2e}$$

In line with [Dietzenbacher and Los \(1998\)](#), the reported contributions of the changes in a determinant are computed by taking the arithmetic averages of two corresponding expressions in (F.1) and (F.2). To compute the contribution of changes in the domestic intermediate inputs requirements matrix  $\mathbf{A}$ , the sum of Eqs. (F.1c) and (F.2c) was divided by two.

F.1. Appendix G

**Table G1**  
Aggregate input coefficient (in %) in 2002–2012.

		Domestic intermediate coefficient	Import coefficient	Value added coefficient	NIVA ratio	Capital income share
2002	<i>D</i>	55.8	1.9	42.3	99.5	37.0
	<i>P</i>	16.8	66.6	16.6	78.3	38.7
	<i>N</i>	58.5	16.3	25.1	80.5	40.3
	<i>Ag</i>	54.3	6.8	38.9	97.4	37.3
2007	<i>D</i>	62.3	3.1	34.7	99.4	43.4
	<i>P</i>	24.1	58.5	17.4	64.4	50.2
	<i>N</i>	59.2	13.7	27.1	74.2	46.9
	<i>Ag</i>	59.5	8.3	32.2	94.7	44.2
2012	<i>D</i>	60.2	3.6	36.2	98.9	36.0
	<i>P</i>	28.4	55.1	16.5	87.3	36.2
	<i>N</i>	65.5	7.4	27.1	73.8	41.8
	<i>Ag</i>	60.3	6.2	33.4	94.0	37.1
2017	<i>D</i>	58.7	3.1	38.2	99.4	36.1
	<i>P</i>	20.0	64.8	15.2	77.6	39.2
	<i>N</i>	61.9	8.7	29.5	76.7	42.2
	<i>Ag</i>	58.4	5.2	36.4	96.3	36.9

Note: *D* = domestic production, *P* = processing exports, *N* = ordinary exports and others, *Ag* = aggregate.

Source: Authors' calculation based on the tripartite IO tables of 2002, 2007 and 2012.

**Table G2**  
Export share for typical industry groups (in %) in 2002–2012.

		Energy and materials	Labor-intensive industries	Machinery	Services	Low-technology industries
2002	P	0.4	8.4	25.2	5.9	14.0
	N	2.1	14.4	8.6	15.6	20.5
	Ag	2.5	22.8	33.8	21.5	34.5
2007	P	0.5	4.6	31.6	2.3	9.0
	N	1.2	14.2	12.2	11.1	25.1
	Ag	1.7	18.8	43.8	13.4	34.1
2012	P	0.4	3.2	28.9	0.0	8.3
	N	0.4	13.3	14.2	18.4	21.5
	Ag	0.8	16.5	43.1	18.4	29.8
2017	P	0.0	1.8	21.6	0.0	4.1
	N	0.9	14.5	22.0	18.3	25.8
	Ag	0.9	16.3	43.6	18.3	29.9

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