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How important are exports for job growth in China? A demand side analysis

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ABSTRACT

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We analyze the impact of foreign demand on Chinese employment creation by extending the global input–output methodology introduced by Johnson and Noguera (2012). We find that between 1995 and 2001, fast growth in foreign demand was offset by strong increases in labor productivity and the net effect on employment was nil. Between 2001 and 2006, booming foreign demand added about 70 million jobs. These jobs were overriding for workers with only primary education. Since 2006 growth in domestic demand for non-tradables has become more important for job creation than foreign demand, signaling a rebalancing of the Chinese economy. *Journal of Comparative Economics* 43 (1) (2015) 19–32. Groningen Growth and Development Centre, Faculty of Economics and Business, University of Groningen, The Netherlands.

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1. Introduction

Exports have played an important role in the structural transformation of the Chinese economy in the past decades. Stimulated by supportive government policy, export activities quickly expanded, absorbing a large part of the abundant rural labor supply. Facilitated by its accession to the World Trade Organization in 2001, China benefitted from the rapid international fragmentation of production and quickly took part in globally integrated production networks (Baldwin, 2006). In 2009, China became the world's largest exporter. The desirability of a strong reliance on foreign demand has been heavily debated, fueled by the volatility and weakness of demand in world markets since the onset of the global crisis in 2008. This has led to repeated calls for stimulating domestic consumption and diverting away from serving foreign demand. At the same time though, it is argued that export-led growth will remain important for sustaining Chinese employment opportunities in the event of a global growth rebound. In addition, decent employment opportunities for the growing pool of college-educated workers are needed (World Bank, 2012).

In order to assess the possible role of foreign demand in generating employment in the future, it is necessary to know how important exports have been in the past. The Chinese economy has undergone a massive structural transformation as about two hundred million workers have found employment in the non-agricultural sector since the 1980s. At the same time the

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Chinese gross-export-to-GDP ratio rapidly increased to a peak of 39% in 2006 (OECD, 2014). How important was foreign demand in generating these new job opportunities, both in absolute terms and relative to domestic demand? And what were the characteristics of the jobs created in terms of sector of employment and skill-level? So far, these questions have not been rigorously addressed in the literature.

Until now, the discussion has mainly been concentrated on the so-called domestic value-added content of exports (Johnson and Noguera, 2012). This metric indicates the value added in the domestic economy as a share of gross export values. Seminal work by Chen et al. (2004) has pointed out that this ratio was only around 60% for China in the early 2000s. They also found a large variation: exports of products that require domestic materials such as textiles had a much higher ratio than exports of products manufactured solely on the basis of imported components, such as electronics manufacturing in export-processing zones. This has been corroborated in later work by Koopman et al. (2012), Pei et al. (2012) and Chen et al. (2012) using comparable industry data and techniques.¹ The use of input–output tables is central in these studies as it allows one to trace not only the value added in the exporting industry, but also in earlier stages of production. For example, Johnson and Noguera (2012) find that although most of the exports are manufacturing products, sizeable value might be added in non-manufacturing sectors delivering material and services inputs further upstream in the production process. This will depend on the strength of the domestic inter-industry linkages as stressed in Hirschman (1958).

An early attempt to measure employment effects of exporting was made by Feenstra and Hong (2010) using input–output tables to capture both the direct and indirect effects. They found that between 1997 and 2002 the employment impact of the increase in exports was much smaller than the impact of the increase in domestic demand. This difference was also found in a study by Chen et al. (2012) for the years 2002 and 2007. They found that the employment impact of a Yuan of processing exports output was much lower than that of non-processing exports, which in turn was lower than that of domestic final demand. This difference in employment impacts was even larger than already suggested by the value-added contents of domestic and foreign demand, as sectors differed greatly in their productivity levels and trends over time.

In this paper we provide for the first time a long-term macro-economic overview of the relative importance of foreign and domestic demand. To account for both direct and indirect effects of exports, an input–output model that captures inter-industry and inter-country linkages in the world economy is required. Existing studies were hampered by two major measurement problems, however. First, official Chinese input–output tables are not revised once published, although statistical practice improved considerably over the years (Holz, 2008; Bosworth and Collins, 2008). As a result, benchmark input–output tables cannot be compared over time. Second, national input–output tables provide information on the use of imported intermediate inputs, but not on their origin. Consequently, previous studies had to assume that the domestic value added content of imports was zero. This might be valid for the past, but as China moves upstream in international production chains, these exports partly return to satisfy domestic final demand (see e.g. Los et al., 2014). Johnson and Noguera (2012) and Koopman et al. (2012) highlighted this “double counting” issue in analyzing gross exports.

We use a newly developed time-series of inter-country input–output tables for 41 countries and regions covering the world economy, called World Input–Output Tables (WIOTs) (Timmer, 2012) that solves for these problems. These WIOTs were constructed by linking national input–output tables over time based on National Accounts series, and across countries through detailed bilateral trade statistics, distinguishing between imports for intermediate and final use. In addition we have collected a new dataset of employment by level of educational attainment at a detailed industry level. This allows us to investigate how foreign and domestic demand has driven the size and the structure of Chinese employment in the long run.

The remainder of the paper is organized as follows. The methodology for measuring induced demand for jobs is discussed in Section 2. We extend the global input–output approach popularized by Johnson and Noguera (2012) and add a decomposition based on employment rather than value added. The construction of the necessary databases for China will be discussed in Section 3. In Section 4, we present our main results and Section 5 provides concluding remarks.

2. Methodology

In this section we outline our approach to measure the extent to which Chinese employment is dependent on foreign demand for final products. We follow the approach adopted by Johnson and Noguera (2012), which is an extension of a standard input–output decomposition technique introduced by Leontief (1936, 1941) toward a multi-country setting. Leontief's seminal insight is rather straightforward and intuitive: to produce output one needs labor, capital and intermediate inputs. These intermediates need to be produced themselves, involving again production factors and intermediates, and so on, until all intermediates are accounted for. He provided a mathematical model which allows one to trace the factor inputs needed in all the stages of production a particular final good. By tracing the value added at all stages of production, it provides an ex-post accounting of the value of final demand. This allows one to measure the importance of foreign demand relative to domestic demand for home-country value added growth, in a consistent framework.² We introduce our accounting framework drawing on the exposition in Johnson and Noguera (2012) and then generalize their approach by adding information on the labor needed in production.

¹ See also studies based on firm and transaction level trade data, such as Upward et al. (2013).

² See Miller and Blair (2009) for an elementary introduction into input–output analysis. This approach is also followed by Bems et al. (2011) in a simulation exercise of the fall in global demand in 2008.

We start by assuming that there are N countries, S industries in each country, and F production factors in each country-industry.³ Output in each industry of each country is produced using domestic production factors (capital and labor) and intermediate inputs, which may be sourced domestically or from foreign suppliers. Output may be used to satisfy final demand or be used as an intermediate input in production, at home or abroad. Final demand consists of household and government consumption and investment.⁴ To track the shipments of intermediate and final goods within and across countries, it is necessary to define source and destination countries, as well as source and destination industries. For a particular product, we define i as the source country, j as the destination country, s as the source industry and t as the destination industry. By definition, when markets clear, the quantity of a product produced in a particular country-industry must equal the quantities of this product used domestically and abroad. Because we only observe the value of products traded, we further assume that each product has only one price, irrespective of its use, such that the revenue for the producer equals the value of use across destinations.⁵ The product market clearing condition can now be written as

$$y_i(s) = \sum_j f_{ij}(s) + \sum_j \sum_t m_{ij}(s, t) \quad (1)$$

where $y_i(s)$ is the value of output in industry s of country i , $f_{ij}(s)$ the value of products sold by this industry for final use in any country j , and $m_{ij}(s, t)$ the value of products sold by this industry for intermediate use by industry t in country j . Products can be used domestically (in case $i = j$) or abroad ($i \neq j$). Although we will apply annual data in our empirical analysis, time subscripts are left out of the equations, for ease of exposition.

Using matrix algebra, the market clearing conditions for each of the SN products can be combined to form a compact global input–output system. Let $\mathbf{y}$ be the output vector of dimension $(SN \times 1)$, the elements of which represent output levels in each country-industry. We further define a global input–output matrix $\mathbf{A}$ of dimension $(SN \times SN)$ with elements $a_{ij}(s, t) = m_{ij}(s, t)/y_j(t)$, which are intermediate input coefficients. These give the cost shares of output from industry s in country i used by industry t in country j . They are defined as the value of intermediate inputs as a share of gross output by the using sector. The matrix $\mathbf{A}$ can be written as

$$\mathbf{A} \equiv \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1N} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{N1} & \mathbf{A}_{N2} & \cdots & \mathbf{A}_{NN} \end{bmatrix},$$

where $\mathbf{A}_{ij}$ is an $S \times S$ matrix with typical element $a_{ij}(s, t)$. The sub-matrices on the main diagonal contain the cost shares of domestically produced intermediate inputs, while the off-diagonal sub-matrices contain the cost shares of foreign intermediate inputs. The matrix $\mathbf{A}$ thus summarizes the input requirements of all intermediate goods across industries and countries. We can use it to rewrite the stacked SN market clearing conditions from (1) as

$$\begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_N \end{bmatrix} \equiv \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1N} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{N1} & \mathbf{A}_{N2} & \cdots & \mathbf{A}_{NN} \end{bmatrix} \begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_N \end{bmatrix} + \begin{bmatrix} \sum_j \mathbf{f}_{1j} \\ \sum_j \mathbf{f}_{2j} \\ \vdots \\ \sum_j \mathbf{f}_{Nj} \end{bmatrix}$$

In this expression, $\mathbf{y}_i$ represents the S -vector with production levels in country i , and $\mathbf{f}_{ij}$ indicates the S -vector of final demands in country j for the products of country i . In compact form, this system can be expressed as

$$\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f} \quad (2)$$

Rearranging (2), we arrive at the fundamental input–output identity introduced by Leontief (1936):

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{f} \quad (3)$$

$\mathbf{I}$ is an $(SN \times SN)$ identity matrix with ones on the diagonal and zeros elsewhere. $(\mathbf{I} - \mathbf{A})^{-1}$ is famously known as the Leontief inverse. It represents the gross output values in all stages of production that are generated in the production process of one unit of final output. To see this, let $\mathbf{z}$ be a column vector with the first element representing the global consumption of products from the first country-industry, while all the remaining elements are zero. The production of final output $\mathbf{z}$ requires intermediate inputs given by $\mathbf{A}\mathbf{z}$. In turn, the production of these intermediates requires the use of other intermediates given

³ We use the term country-industry to denote an industry in a country, such as the Chinese chemicals industry and the German transport equipment industry.

⁴ In the input–output tables these final demand categories are separately modeled, but they are taken together for the empirical analysis.

⁵ In the empirical analysis we will use input–output tables at basic prices, which exclude trade and transportation margins and net taxes. This price concept is most in line with the assumption made here.

by $\mathbf{A}(\mathbf{A}\mathbf{z})$, and so on. As a result, the increase in gross output in all industries is given by the sum of all direct and indirect effects $\sum_{k=0}^{\infty} \mathbf{A}^k \mathbf{z}$. This geometric series can be rewritten as $(\mathbf{I} - \mathbf{A})^{-1} \mathbf{z}$. This represents the gross output levels in each of the SN industries that are induced by global final demand for the products of the first country-industry. It should be noted that this method is based on repeated proportional attribution of inputs, as it is assumed that the amounts of inputs needed per unit of output in a particular industry are independent of the use of its outputs. If each industry produces only one product, this assumption would be innocuous. But typically firms in an industry produce various products. The plausibility of this assumption will thus depend on the level of detail in the empirical data, as discussed later.

To link final demand to employment creation, we need to model the production process more explicitly. Let the quantity of output in an industry be a standard function of the quantities of labor, capital and intermediate inputs used. By the usual accounting definition, the value of output of the industry is then equal to the value of all inputs used, and is expressed in dollars in our data. Let $y_i(s)$ be the value of output in industry s of country i , and let $l_i(s)$ the number of workers in this industry, then we can define $p_i(s)$ as the number of workers required per dollar output in industry s in country i : $p_i(s) = l_i(s)/y_i(s)$, and create the column vector $\mathbf{p}$ with dimension $\text{SN} \times 1$. Importantly, the elements in this vector are country- and industry-specific such that the number of workers used to produce one dollar of gross output in the Chinese electronics industry may be different from that in the Chinese chemicals industry and also different from that in the German electronics industry, for example. The requirement vector $\mathbf{p}$ indicates the labor per dollar output needed in one particular production stage. We define a new vector $\mathbf{k}$ that indicates labor needed in all stages of production of a final product. We derive this labor inducement vector $\mathbf{k}$ (with SN elements) for any final demand vector $\mathbf{f}$ by post-multiplying the requirement vector $\mathbf{p}$ with the gross outputs needed for production of this final demand as derived in (3):

$$\mathbf{k} = \hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1} \mathbf{f} \quad (4)$$

where a hat indicates a diagonal matrix with the elements of a vector on the diagonal. If the final demand vector $\mathbf{f}$ is chosen specifically (like $\mathbf{z}$ above), the vector $\mathbf{k}$ as obtained in Eq. (4) gives the labor (directly and indirectly) needed for the production of the specific final demand vector that is analyzed. If, for example, $\mathbf{f}$ is chosen to represent worldwide final demand for the products sold by the Chinese textile industry, $\mathbf{k}$ represents the labor required in each country-industry in the world to meet this demand. This will include labor used in the Chinese textile industry itself, but also in more upstream industries delivering intermediate goods and services required to produce textiles. These industries will be located in China and abroad.

To analyze the importance of demand for employment we define foreign final demand ($\mathbf{f}_i^{\text{FOR}}$) and domestic final demand ($\mathbf{f}_i^{\text{DOM}}$) as the following SN vectors:

$$\begin{bmatrix} \sum_{j \neq i} \mathbf{f}_{1j} \\ \sum_{j \neq i} \mathbf{f}_{2j} \\ \vdots \\ \sum_{j \neq i} \mathbf{f}_{Nj} \end{bmatrix} = \mathbf{f}_i^{\text{FOR}} \quad \begin{bmatrix} \mathbf{f}_{1i} \\ \mathbf{f}_{2i} \\ \vdots \\ \mathbf{f}_{Ni} \end{bmatrix} = \mathbf{f}_i^{\text{DOM}}$$

which implies that $\mathbf{f}_i^{\text{FOR}} + \mathbf{f}_i^{\text{DOM}} = \mathbf{f}$. If i corresponds to China, $\mathbf{f}_i^{\text{DOM}}$ represents final demand by China for output of any of the SN country-industries in the world, while $\mathbf{f}_i^{\text{FOR}}$ gives the final demand by all other countries. Substituting $\mathbf{f}_i^{\text{FOR}} + \mathbf{f}_i^{\text{DOM}} = \mathbf{f}$ in the linear system given in Eq. (4):

$$\mathbf{k} = (\hat{\mathbf{p}})(\mathbf{I} - \mathbf{A})^{-1} \mathbf{f}_i^{\text{DOM}} + (\hat{\mathbf{p}})(\mathbf{I} - \mathbf{A})^{-1} \mathbf{f}_i^{\text{FOR}} = \mathbf{k}^{\text{DOM}} + \mathbf{k}^{\text{FOR}} \quad (5)$$

In this equation, we have decomposed the labor used in each country-industry into the amount induced by final demand from China ($\mathbf{k}^{\text{DOM}}$) and from other countries ($\mathbf{k}^{\text{FOR}}$).⁶ By definition, this decomposition is exhaustive.

Given that we have annual data for all variables in Eq. (5), we can study changes over time. In particular let Δ indicate the change over the period between time 0 and 1, and subscripts indicate time. Then

$$\Delta \mathbf{k}^{\text{FOR}} = (\hat{\mathbf{p}}_1)(\mathbf{I} - \mathbf{A}_1)^{-1} \mathbf{f}_{i,1}^{\text{FOR}} + (\hat{\mathbf{p}}_0)(\mathbf{I} - \mathbf{A}_0)^{-1} \mathbf{f}_{i,0}^{\text{FOR}} \quad (6)$$

It shows that changes in the labor induced by foreign demand depend on three main elements: changes in labor requirements, changes in the intermediate input structure and changes in the level of final demand. We will use this property to decompose trends in employment in Chinese industries.

A number of issues need further elaboration. First, one might note that if export production does not require intermediate inputs from the domestic economy (directly or indirectly), the decomposition is trivial as domestic employment effects can be gauged directly from the requirement vector $\mathbf{p}$. China used to have a sizeable share of exports originating from export processing zones (EPZs) in which this is the case, but their importance is shrinking (Chen et al., 2012) as the economy becomes more sophisticated and more intermediates are produced at home. Firms outside EPZs produce both for domestic

⁶ In this paper we are only interested in the demand for Chinese labor and hence we set all non-Chinese elements in the requirement vector $\mathbf{p}$ to zero.

and foreign demand, and produce intermediates as well as final goods. These flows can only be accounted for by using an input–output model as outlined above.

Second, the decomposition is an ex-post analysis. It uses exogenously given final demand and traces induced demand for jobs without explicitly modeling the interaction of prices and quantities that are central in full-fledged Computable General Equilibrium models (see, for example, Levchenko and Zhang, 2012). While CGE models are richer in the modeling of behavioral relationships, there is the additional need for econometric estimation of various key parameters of production and demand functions. With intermediate inputs that can be sourced domestically as well as abroad, a central feature of global production systems, the number of parameters to be estimated rapidly increases. Instead, we rely on a reduced form model in which input cost shares and labor requirements are known, and assume that these would not change for counterfactual levels of final demand (that is f_i^{DOM} and f_i^{FOR} rather than f_i).

Third, the time series of world input–output tables on which we base our empirical analysis are expressed in current US dollars. This implies that labor requirements coefficients $p_i(s)$ are sensitive to inflation, since the numerators of such coefficients are expressed in quantities (numbers of workers), while the denominators are expressed in values (dollars of gross output). However, final demand levels are also affected by inflation. Hence, price changes will cancel out in the decomposition in Eq. (5), unless price developments of products traded to foreign markets diverge from price changes of the same products sold for domestic consumption. There is no evidence that this is systematically the case.

Fourth, the empirical relevance of our method depends crucially on the level of detail for which data is available. An unavoidable assumption in the decomposition is that the requirement $\mathbf{p}$ for a particular year is the same for all outputs of an industry, irrespective of their use (intermediate or final, exported or not). The higher the level of industry detail in the data, the less binding this assumption will be. We use detailed data for 34 industries, so differences in the composition of domestic and foreign demand in terms of products demanded will be clearly reflected in our results. It should also be noted that our approach does not imply that we assume that intermediate input cost shares and labor requirements are held constant over time. As will be emphasized in the next section, the data for elements of $\mathbf{p}$, $\mathbf{A}$, f_i^{DOM} and f_i^{FOR} vary on an annual basis.

3. Data sources and implementation framework

To implement the accounting method outlined above, one needs a database with linked consumption, production and income flows both within and across countries. We use the newly constructed World Input–Output Database, briefly discussed in Section 3.1. Given the complex nature of the Chinese statistical system and idiosyncrasies in its reporting practices, particular attention is needed for the choice and treatment of Chinese input–output statistics in Section 3.2 and factor requirements in Section 3.3.

3.1. World Input–Output Tables (WIOTs): concepts and construction

For this paper we use a new database that provides a time-series of World Input–Output Tables (WIOTs) from 1995 onwards, distinguishing between 35 industries and 59 product groups (see appendix Table A.1 for the industries distinguished). Here we provide only a very brief discussion of the main characteristics of the WIOTs. More details can be found in the appendix and extensive documentation is given in Timmer (2012) and Dietzenbacher et al. (2013). All WIOTs and underlying data sources are publicly available for free at www.wiod.org. WIOTs are based on national input–output tables of forty major countries in the world, linked through international trade statistics, covering more than 85% of world GDP, plus a model for the remaining non-covered part of the world. WIOTs have been specifically constructed to allow for both cross-country and intertemporal comparisons by benchmarking them to the concepts and statistics from the National Accounts, and a common industrial classification (International Standard Industrial Classification revision 3). Typically, input–output tables are only available for a limited set of years (e.g. every five year) and once released by the national statistical institute revisions are rare. To remedy this, WIOTs have been constructed on the basis of National Accounts time series and benchmark input–output tables, ensuring both intercountry and intertemporal consistency of the tables. A second characteristic of the WIOTs is that the supply of products is broken down by country and industry of origin. National tables were linked through a classification of bilateral import flows by three end-use categories using detailed international trade statistics (see Appendix A for more detail).

3.2. Time series of input–output tables for China

To estimate the Chinese part of the WIOTs, use has been made of detailed national input–output tables for the benchmark years 1992, 1997, 2002 and 2007, combined with additional supply and use tables. The IO-tables are of the product-by-product type and at producer prices. Tables for 1992 and 1997 use the Chinese Standard Industrial Classification (CSIC) 1994 and tables for 2002 and 2007 use the CSIC 2002. Both classifications have been mapped into the ISIC revision 3 used in WIOD.⁷ All

⁷ Industry concordances with the international industry classification system are available from the authors upon request. The main problems related to the distributive trade industry. Sales data from the China First Economic Census 2004 was used to split trade into wholesale and retail trade.

tables are publicly available from the [Chinese National Bureau of Statistics \(NBS 1995, 1999, 2006, 2009\)](#). The input–output tables provide more industry detail (about 120 commodities) and are of higher quality than the published supply and use tables. To generate detailed supply tables, the main diagonal elements have been taken from the IO-tables combined with secondary production information from the supply table in estimating the non-diagonal elements (only available for mining, various manufacturing industries, and public utilities). The use table is derived from the IO-tables by mapping each product to the industry that is primary in its production. A standard RAS-procedure was used to obtain row and column consistency.

Two important idiosyncrasies of the Chinese tables had to be dealt with, namely the treatment of industrial processing services, and the recording of statistical discrepancies. First, the published Chinese input–output tables have a column called “Errors” that reflect the statistical discrepancy between use (intermediate inputs + final demand) and supply (=gross output + import) which can be up to five percent of total supply.⁸ We distributed the error in each product across final demand proportionally to the shares in final demand. Second, the treatment of import and export data for export processing production changed between the construction of the 2002 and the 2007 input–output tables. In the latter table, the export and import data exclude those goods that are used in industrial processing services. Instead, only the value added generated in the processing by Chinese firms is recorded as exports. The excluded goods for processing are related only to those goods that are directly provided by foreign firms. In an appendix table of the official NBS input–output publication (NBS, 2009), additional information is given on the size of these flows. The share of the excluded goods for processing in total imports is about 9%, with much higher shares at the product level (imports of textiles, for example, increase by 40%). To maintain consistency with earlier tables and international practice, we added the excluded goods for processing to exports and to the imported intermediate use block. Ideally we would have liked to make a distinction between production for domestic demand and for exports. There is some information on the difference between processing and non-processing export activities which has been used by [Chen et al. \(2012\)](#) for example. This data is not public however, and in particular the inter-temporal consistency is unknown.

Official Chinese input–output tables are not revised once published. However, the Chinese statistical system improved considerably over the years. For example, Chinese GDP series have been heavily revised in 2006 when the results of the Economic Census of 2004 became available, partly due to an underrepresentation of the services industries in previous series ([Holz, 2008](#); [Bosworth and Collins, 2008](#)). As a result benchmark input–output tables cannot be compared over time. We benchmark final demand category totals as well as industry intermediate use and value added from the IOTs to those from the National Accounts to allow for intertemporal consistency. The value added series by main sector for China are from the *China Statistical Yearbook* (CSY) published by the [NBS \(2011 issue with data up to 2010\)](#). The CSY provides longitudinal series for five broad sectors of the economy, namely agriculture, industry, construction, transportation and commerce, and other services. In additional tables, the CSY provides more detailed information for services industries, but the sum of these industries is not consistent with the sector totals. Shares, in combination with additional information, were adjusted such that the more detailed series by industry are consistent with the totals for services. For detail in manufacturing industries, gross value added shares by industry were obtained from the industrial statistics published in the *China Industrial Economic Statistics Yearbook* by the NBS Department of Industrial and Transportation Statistics.⁹

3.3. Factor input requirement data for China

Employment is defined as ‘all persons engaged’, including all paid employees, but also self-employed and informal workers. Employment series by three broad sectors for China are from various issues of the *China Statistical Yearbook* and match those used by [Bosworth and Collins \(2008\)](#). Detailed industrial employment series for 35 industries are based on various issues of the *China Industrial Economic Statistics Yearbook* (CIESY) and the *China Labor Statistical Yearbook* (CLSY). The CIESY provides employment data at a detailed level for enterprises at or above the “designated size”. In addition, the CLSY provides data for all enterprises including all below the “designated size”, but at a lower level of detail. In principle, we follow the industry data construction as in [Wu and Yue \(2010\)](#).¹⁰ The detailed industry level estimates are reconciled using the three broad-sector estimates in [Wu \(2011\)](#) and national totals as controls (see [de Vries et al., 2012](#), for further discussion).

Employment by detailed industry is split further by educational attainment levels using the 2004 *Economic Census*, which distinguishes between: junior school and below; high school; vocational college; undergraduates; and graduates and above. Junior school and below is mapped into “low-educated”, High school and vocational college into “medium-educated” and undergraduates and above into “high-educated”, following [Wu and Yue \(2010\)](#) and the definitions given in [UNESCO \(2007\)](#). The education shares for the 34 industries are extrapolated for the period from 2002 to 2008 using trends for fifteen more aggregate industries from the *China Labor Statistical Yearbook*. The educational level of workers in agriculture has been assumed to be low-skilled by definition. For years before 2002, economy-wide growth rates in primary (for low-educated),

⁸ Personal correspondence with the NBS indicated that if the error gets larger than five percent of total supply, the excess error is moved to changes in inventories and valuables.

⁹ There are some conceptual discrepancies between the National Accounts series thus derived and the IO-table for 2007, but they are relatively minor (amounting to 2% or less depending on the final demand category considered) and relate to different treatment of import margins and financial intermediation services indirectly measured (see [Zhao, 2010](#)). The data for 2011 is based on OECD National Accounts, using higher aggregates growth rates for detailed industries.

¹⁰ They use all industry level census data (namely China's 1985 and 1995 Industrial Censuses and the 2004 and 2008 Economic Censuses) to estimate consistent employment data above and below “designated size”, and those outside the “system”, basically the self-employed and informal workers. The latter are allocated only to labor-intensive industries. See also [Banister and Cook \(2011\)](#) for an in-depth analysis of manufacturing employment statistics.

Fig. 1. International comparison of share of countries' GDP induced by foreign final demand. *Notes:* Share of GDP induced by foreign final demand. This is based on Eq. (5) using time series of country- and industry-specific value added to gross output ratios as the requirements vector. *Source:* Authors' calculations based on World Input–Output Database, November 2013.

secondary (for medium-educated), and tertiary (for high-educated) educational attainment are used from Barro and Lee (2010).

4. Empirical results

In this section we describe our findings on the importance of foreign demand for employment in the Chinese economy since 1995, using the accounting methodology outlined in Section 2. To provide an international comparative perspective, we first analyze the impact of foreign demand on value added (Section 4.1) for a range of countries. We then discuss our main analysis of the impact of foreign and domestic demand on the generation of employment opportunities in Chinese industries in general (Section 4.2), and more specifically for different types of worker skills (Section 4.3). Depending on data availability we will study the period up to 2011 (for value added) or 2009 (for employment).

4.1. The importance of foreign demand for value added

To put the dependence of China on foreign demand in a comparative perspective we decompose GDP of countries into the amount induced by domestic and foreign final demand. The latter is referred to as “value added exports” by Johnson and Noguera (2012). It indicates the amount of domestic value added that is ultimately embodied in final products consumed abroad. Final demand includes both household and government consumption, as well as investment demand. To this end, we apply decomposition Eq. (5), but use value added to gross output ratios elements in vector $\mathbf{p}$, where value added is defined as usual as the value of gross output minus the value of intermediate inputs.

In Fig. 1 we provide exports of value added as a percentage of GDP for a selected group of countries. For China the ratio was 19% in 1995 and remained fairly stable until 2001. After China's accession to the WTO in 2001 it rapidly increased to a peak of 28% in 2006, indicating an increasing dependence of domestic income on serving foreign final demand. But since then, foreign demand dependence has dropped and hovered around 21%. These shares are much lower than the share of gross exports in GDP, as the domestic value added content of exports is well below one, reflecting the findings by Johnson and Noguera (2012).

The inverted U-curve pattern found for China is not exceptional. Our international comparison shows similar patterns for other fast growing emerging economies such as Brazil, India and Turkey. Russia and Indonesia also became steadily less and less dependent on foreign demand from 2000 onwards. What is more striking about the Chinese dependence on foreign demand for final products, however, is its high level. In general, there appears to be a negative relationship between the size of the economy and its dependence on foreign demand. Chinese levels are rather high given its size, but again not exceptional. In 2011 its level came close to that of Mexico (not shown), which is closely connected with the US through the North-American Free Trade Agreement. The level of foreign dependence is also high in Germany and in Russia, comparable to Chinese levels. Smaller countries like Austria, Belgium, the Netherlands, Sweden, South Korea and Taiwan have even higher ratios (Timmer et al., 2013).

4.2. The importance of foreign demand for employment

One of the main reasons for stimulating exporting activities by Chinese policy makers was the promise of abundant job creation, providing a way to absorb the massive rural labor surplus. How successful was the export drive in generating employment compared to domestic demand? We investigate this by using the decomposition in Eq. (5). Employment is

Table 1

Change in number of workers induced by final demand (millions). Source: Authors' calculations based on World Input–Output Database, November 2013.

	Domestic final demand for		Foreign final demand	All demand
	Tradables	Non-tradables		
1995–96	5.7	15.8	–12.7	8.9
1996–97	0.9	0.6	7.2	8.7
1997–98	–8.1	20.6	–4.3	8.2
1998–99	–1.3	12.2	–3.3	7.6
1999–00	–9.4	6.4	10.0	6.9
2000–01	–2.3	13.2	–1.5	9.4
2001–02	–12.2	7.3	12.1	7.2
2002–03	–12.3	2.9	16.3	6.9
2003–04	–6.3	0.1	13.9	7.7
2004–05	–20.0	9.3	16.9	6.2
2005–06	–14.8	9.1	11.4	5.8
2006–07	–3.7	7.1	2.6	5.9
2007–08	5.5	12.0	–12.6	4.9
2008–09	1.8	28.1	–24.8	5.2
1995–01	–14.7	68.9	–4.6	49.6
2001–06	–65.6	28.7	70.6	33.8
2006–09	3.6	47.2	–34.8	16.0
1995–09	–76.7	144.8	31.2	99.3

Notes: Change in number of workers induced by final demand in a particular period. Demand is split into foreign final demand, domestic final demand for tradables (agricultural and manufacturing products) and domestic final demand for non-tradables (all other products). Calculation based on decomposition by source of final demand in Eq. (6) using time series of workers to gross output ratios at the industry level as the requirements vector $\mathbf{p}$.

measured as the number of workers including employees and informal workers, as discussed in the previous section.¹¹ The elements in $\mathbf{p}$ are for 34 industries of the economy and change over time. In addition, to investigate the importance of services demand we split domestic final demand vector $\mathbf{f}^{\text{DOM}}$ in Eq. (5) into domestic demand for tradable goods (agricultural and manufacturing products) and domestic demand for non-tradable goods and services (other products). Effectively we decompose the changing final demand for Chinese labor into three sources: foreign demand, domestic demand for tradables and domestic demand for non-tradables.¹² The results are given in Table 1 and Fig. 2, which show the annual change in the number of jobs induced by foreign and domestic demand as given by Eq. (6).

The total number of workers in the Chinese economy has gradually increased from 681 million in 1995 to 780 million in 2009 which corresponds to an increase of 99 million, but the contributions of foreign and domestic demand to this increase varied widely over time. As Fig. 2 clearly shows, three sub-periods can be distinguished. They correspond to the trends for export of value added found above. During 1995–2001 domestic demand was by far the most important source of increased job demand adding more than 50 million jobs, while the number of jobs satisfying foreign demand actually decreased by about 5 million. This reversed in the period 2001–2006. In this period foreign demand was by far the most important source of employment generation in each year, adding 71 million jobs in total over the whole period.¹³ In contrast jobs induced by domestic demand decreased by about 37 million (this decline is due to strong improvements in labour productivity as discussed below). From 2006 onwards however, growth in domestic demand once again generated more jobs than growth in foreign demand. In the early years of the financial crisis, strong reductions in consumption and investment demand in advanced countries led to a shift toward a stronger dependence on domestic markets. In the period 2006–2009, 35 million jobs associated with foreign final demand were lost and domestic demand for non-tradables became again the main driver of employment growth in China.

Earlier work by Feenstra and Hong (2010) and Chen et al. (2012) suggested that the employment impact of demand growth crucially depends on levels and growth rates of labor productivity of the various activities. The employment effect of foreign demand is mainly a race between increases in productivity levels and demand levels, as higher productivity leads to less induced demand for labor, given a certain demand level. In particular, the employment effects of growing exports might be much lower than suggested by its increasing share in GDP. We will analyze this conjecture in a more formal way.

Let labor productivity be defined as usual, as value added per worker. Then it is equal to the inverse of the labor requirement (i.e. dollar output per worker) times the ratio of value added to dollar output. We can therefore expand the decomposition in Eq. (5). In particular, we will look at labor demand growth in a period (say 1995–2001) in the counterfactual

¹¹ We will use the terms workers and jobs interchangeably, but our measures are based on number of workers classified by primary occupation.

¹² It should be noted that this decomposition into demand sources is not identical to a sectoral decomposition of employment. Given that both manufacturing goods and services are used in the production of goods, as well as in the production of many services, there is not a one-to-one correspondence of final demand and sectoral value added structures, as stressed by Herrendorf et al. (2013).

¹³ Our findings correspond closely to the ones by Feenstra and Hong (2010). They found that 12.5 million jobs were added due to foreign demand during 1997–02, comparable to our 13.0 million. They also tried to estimate the effects for later years but did not have employment data. Instead they used wage trends to estimate labor productivity growth which were used to implicitly back out labor demand. Wage trends do not follow productivity trends however, leading to wildly fluctuating predictions. Instead, in this study we use actual employment statistics.

Fig. 2. Change in number of workers induced by domestic and foreign final demand (in millions). *Note:* Based on Eq. (6) using time series of industry specific workers to gross output ratios as the requirements vector $\mathbf{p}$. *Source:* Authors' calculations based on World Input–Output Database, November 2013.

Table 2

Sector of employment of workers induced by foreign final demand (percent). *Source:* Authors' calculations based on World Input–Output Database, November 2013.

	1995 (%)	2009 (%)	2009 minus 1995 (%)
Manufacturing	28.9	37.2	8.3
Agriculture	42.0	32.8	−9.2
Other sectors	29.1	30.0	0.9
Total economy	100.0	100.0	0.0

Note: Based on Eq. (5) using time-varying industry-specific workers to gross output ratios as the requirements vector $\mathbf{p}$.

situation of no labor productivity growth. The counterfactual labor demand in 2001 is derived from Eq. (5), by keeping labor productivity at its 1995 level and letting the intermediate input requirements, final foreign demand, as well the value added to gross output ratio take their actual levels in 2001.¹⁴

For this period the number of jobs induced by foreign demand would have increased by 57 million if there was no productivity growth. Instead, it dropped by 5 million. Labor productivity was rapidly increasing in the late 1990s as a strong process of restructuring took place in state-owned enterprises in industries such as textiles, chemicals, metals and machinery (Cao et al., 2009). Only after 2001, employment induced by foreign demand took off concomitant with policy-makers' expectations. Labor productivity still increased rapidly, but now booming foreign demand outpaced this. The net effect was adding 71 million jobs over the period from 2001 to 2006. Without the productivity improvement the job additions would be even more than double: 146 million.

Rapid productivity improvement in the production for exports is a combination of within- and between-industry effects. Productivity increased in many industries (see also Bosworth and Collins, 2008) but on top of that demand shifted to goods the production processes of which have higher productivity levels. In 1995, 37% of foreign final demand for Chinese products was for textiles, wearing apparel and footwear (products from ISIC rev. 3 industries 17, 18 and 19) and 25% for electrical and non-electrical machinery (industries 29 to 33). In 2006, these shares were respectively 24% and 48%. As productivity levels in machinery production are about twice that in textiles production, this shift in the product composition of foreign demand added to the productivity growth in individual industries, dampening the employment impact of booming foreign demand.

One might still argue that our method overestimates the importance of exports for job demand due to our assumption that production technologies are the same for all demand sources. Production for export might be less labor intensive when exporting firms are more productive than firms producing for the domestic market, e.g. because they operate more productive technologies. Given our data, we are able to control for differences in production technologies across industries, and hence for difference in the product composition of foreign and domestic demand, but not for differences within industries. Pioneering work in this area is the modeling of a separate export processing sector in the input–output tables as in Chen et al. (2012) and Koopman et al. (2012). This is one step in the right direction but the problem remains at lower levels of aggregation. On-going work based on micro-databases should allow us to get a better insight into the heterogeneity of firms in terms of value added and factor use, linked to their exporting and ownership status. For example Ma et al. (2014) find that Chinese firms that start exporting become less capital-intensive but more productive after exporting, compared to non-exporters that share similar ex ante characteristics (see also Ma et al., 2013 and Manova and Yu, 2014).¹⁵

¹⁴ The time series of world input–output tables on which we base our empirical analysis are expressed in current US dollars. We deflate all nominal values by the Chinese GDP deflator and the exchange rate.

¹⁵ But the problem remains at an even lower level of aggregation. Upward et al. (2013, p. 532) find that over 40% of the firms in their sample have both processing and normal trade.

Table 3

Change in number of workers induced by source of final demand and level of educational attainment (millions). *Source:* Authors' calculations based on World Input–Output Database, November 2013.

	1995–01	2001–06	2006–09	1995–09
Foreign demand for	–4.6	70.6	–34.8	31.2
Low-educated	–12.9	50.5	–25.1	12.4
Medium-educated	6.9	14.9	–8.0	13.7
High-educated	1.4	5.3	–1.7	5.0
Total demand for	49.6	33.8	16.0	99.3
Low-educated	4.3	–4.7	–4.1	–4.6
Medium-educated	36.3	16.9	15.8	69.0
High-educated	9.0	21.6	4.2	34.9

Note: Decomposition of workers induced by demand source and educational attainment based on Eq. (6), using time-series of industry specific workers by educational attainment to gross output ratios as the requirements vector $\mathbf{p}$.

In which sectors were jobs created to satisfy foreign demand? Chinese exports mainly consists of manufacturing goods. However, this does not mean that only jobs in manufacturing have been created. Services and agricultural activities can be important contributors to the production of manufacturing goods, providing intermediate inputs, such as business, transport and energy services, as well as raw materials such as cotton and food stuffs (Hirschman, 1958). While this will be low for exports originating from processing zones, it might be high for exports produced outside these zones. To investigate this, we keep track of the sector of employment of the workers induced by foreign demand in the decomposition provided by Eq. (5).

In Table 2 we provide the distribution of workers induced across three main sectors of the economy: agriculture, manufacturing and other industries (including mining, utilities, construction and services). For example, textile production has strong backward linkages into domestic agriculture. Indeed, in 1995 only 29% of the jobs induced by foreign demand originated in the manufacturing sector, while the majority originated in agriculture.¹⁶ But the sectoral division changed rapidly. In 2009 more than one-third of these jobs were to be found in manufacturing, and the share in agriculture dropped to less than one-third. This shift in employment structure might be more important than suggested on the basis of bare job count. Most of the jobs in manufacturing are in the context of an employee-based factory system. This type of salary-employment might provide more security and stability in terms of income and jobs than informal self-employment in other sectors.¹⁷

4.3. The importance of foreign demand for skills

Another motive for stimulating export activity was the need for a rebalancing in the structure of labor demand for higher skills. The placement of the growing supply of university students into good jobs has aroused much concern (World Bank, 2012). Partly to reduce unemployment after the 1997 Asian financial crisis, China hugely increased the number of students in higher education. Did export promotion contribute to the employment of the higher-educated? One might hypothesize that as exports mainly originate from the manufacturing sector they will have a higher skill-content than domestic-demand induced jobs. However, as shown in the previous section due to linkages between industries in the economy many jobs are created outside manufacturing. Moreover, jobs in manufacturing are not necessarily skill demanding. Activities such as assembly, testing and packaging require little educational attainment. And much of Chinese manufacturing for exporting is likely to consist of this type of activities.

To investigate this, we split for each year the labor force in each industry into low-educated, medium-educated and high-educated workers as described in Section 3. The ratios of workers by type to dollar output in each industry are used as the elements of the requirement vector $\mathbf{p}$ in our decomposition Eq. (5). The results for the number of jobs generated by foreign demand in three sub-periods are given in Table 3, together with the numbers for total demand (foreign and domestic combined) to put the contribution of exports into perspective.

First however, it is instructive to compare the skill content of jobs induced by one Yuan worth of foreign and domestic demand. This ratio is shown in Fig. 3. In 1995, the skill content of the two demand sources was comparable with ratios close to one. During the period 1995–2001 the skill content of foreign demand production increased as both medium- and high-educated worker intensity increased relative to production for domestic demand, while low-educated intensity declined. But this reversed in the period after: skill intensity of production for foreign demand rapidly declined, and this trend continued in the global crisis period. As a result, the number of jobs for high-educated workers induced by foreign demand was rather limited. Even in its boom period (2001–2006) exports raised demand for high-educated workers only by 5 million, compared to 22 million increase due to domestic demand (see Table 3). Similarly, only 15 million jobs for medium-educated workers were added by foreign demand in this period. Instead the majority of the jobs created were for low-educated workers (51 million).

This finding is in line with Upward et al. (2013), who found that Chinese exports contained relatively little human capital as measured by the proportion of workers with higher-education or professional qualifications (the two measures appeared

¹⁶ Johnson and Noguera (2012) also find that the contribution from agriculture to value-added exports of manufacturing goods can be sizeable. Agricultural contributions in terms of jobs will be higher than in terms of value added due to lower labor productivity levels in agriculture.

¹⁷ This observation was pointed out to us by Adrian Wood.

Fig. 3. The skill content of employment induced by foreign demand relative to domestic demand. *Note:* Ratios of number of jobs induced by one Yuan of foreign demand to number of jobs induced by one Yuan of domestic demand for low-, medium- and high-skilled workers, defined by level of educational attainment (see Section 3). Based on Eq. (5), using industry specific workers by skill-type to gross output ratios as the requirements vector $\mathbf{p}$. *Source:* Authors' calculations based on World Input–Output Database, November 2013.

to be highly correlated). Based on firm-level evidence they found that export intensity was significantly higher in less skill-intensive industries. Overall, skill-intensity of exports rose over the period 2000–2007 but this was predominantly due to a shift of export shares between industries, rather than an upgrading within industries. It suggests that the set of activities carried out in China during its export boom was heavily dominated by routine activities that required little skills. Without upgrading to more skill-intensive activities it will be hard to find sufficient employment opportunities for the growing group of college-educated workers. So far these were mainly absorbed due to increasing domestic, rather than foreign demand.

In parallel with employment effects, one might argue that our method understates the importance of exports for skill demand. Skill-intensity differences across industries are distinguished in our data, but skill-intensity differences across firms within industries are not. So it might for example be that electronics destined for export have a higher quality than electronics for domestic consumption. If this higher quality is correlated with use of more skilled workers, we might be underestimating the skills-intensity of jobs induced by foreign demand, but so far no evidence is available to corroborate this.

5. Concluding remarks

In this paper we analyzed the role of foreign demand in driving employment growth in China since 1995 based on an ex-post global input–output analysis. We extended the methodology introduced by Johnson and Noguera (2012) and applied this to a new time-series database of world input–output tables combined with new industry-level data on employment by skill type for China. We found that in the period 1995–2001, increasing exports did not generate additional jobs as improvements in labor productivity outpaced the growth of foreign demand. Only after 2001 foreign demand became the dominant source of employment generation adding about 13 million jobs annually. This reversed again in 2006 as exports became less important and domestic demand for non-tradable goods increased, generating large employment opportunities. We also found that foreign demand induced mainly jobs for low-skilled workers, and did little to generate new employment opportunities for high-skilled workers, even during the boom period 2001–2006. We conclude that exporting was not a major force in providing more employment opportunities for the expanding skilled labor force in the Chinese economy.

Our estimates are the first to provide a macro-economic analysis of the employment effects of various sources of demand. But we would like to stress that our findings are mainly explorative and mention two caveats in particular. First, consistent time-series data on Chinese output, employment and wage incomes by industry are notoriously hard to construct. Although we have drawn on the most sophisticated estimates to date, there remains considerable doubt on the numbers as estimates from various sources are hard to reconcile. Second, due to lack of data, we are not able to separately model production for domestic and foreign demand. If for example exporting firms in the same industry have lower employment to gross output ratios compared to non-exporters, employment induced by foreign demand will be overestimated at any point in time. Alternatively, if production for exports requires higher skills than production for domestic demand, we might have underestimated the export-induced demand for skills. More work on longitudinal firm-level databases should help to chart the trends presented in this paper in more detail. It is likely though, that our main conclusion will remain: the importance of foreign demand for Chinese employment was much less than suggested by its high gross exports to GDP ratios, and since 2006 exports are no longer the main generator of new jobs.

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		Country A	Country B	Rest of World	Country A	Country B	Rest of	
		Intermediate	Intermediate	Intermediate	Final	Final	Final	
	Industry	Industry	Industry	Industry	domestic	domestic	domestic	Total
Country A	Industry	Intermediate use of domestic output	Intermediate use by B of exports from A	Intermediate use by RoW of exports from A	Final use of domestic output	Final use by B of exports from A	Final use by RoW of exports from A	Output in A
Country B	Industry	Intermediate use by A of exports from B	Intermediate use of domestic output	Intermediate use by RoW of exports from B	Final use by A of exports from B	Final use of domestic output	Final use by RoW of exports from B	Output in B
Rest of World (RoW)	Industry	Intermediate use by A of exports from RoW	Intermediate use by B of exports from RoW	Intermediate use of domestic output	Final use by A of exports from RoW	Final use by B of exports from RoW	Final use of domestic output	Output in RoW
		Value added	Value added	Value added				
		Output in A	Output in B	Output in RoW				

Fig. A.1. Schematic outline of World Input–Output Table (WIOT), three regions.

Table A.1

Industries distinguished in WIOD.

Code	NACE	Description
1	AtB	Agriculture, hunting, forestry and fishing
2	C	Mining and quarrying
3	15t16	Food, beverages and tobacco
4	17t18	Textiles and textile products
5	19	Leather, leather and footwear
6	20	Wood and products of wood and cork
7	21t22	Pulp, paper, printing and publishing
8	23	Coke, refined petroleum and nuclear fuel
9	24	Chemicals and chemical products
10	25	Rubber and plastics
11	26	Other non-metallic mineral
12	27t28	Basic metals and fabricated metal
13	29	Machinery, nec
14	30t33	Electrical and optical equipment
15	34t35	Transport equipment
16	36t37	Manufacturing, nec; recycling
17	E	Electricity, gas and water supply
18	F	Construction
19	50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
20	51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
21	52	Retail trade, except of motor vehicles and motorcycles; repair of household goods
22	H	Hotels and restaurants
23	60	Inland transport
24	61	Water transport
25	62	Air transport
26	63	Other supporting and auxiliary transport activities; activities of travel agencies
27	64	Post and telecommunications
28	J	Financial intermediation
29	70	Real estate activities
30	71t74	Renting of M&Eq and other business activities
31	L	Public admin and defence; compulsory social security
32	M	Education
33	N	Health and social work
34	O	Other community, social and personal services
35	P	Private households with employed persons

Agreement no: 225 281. More information on the WIOD-database can be found at www.wiod.org. We are grateful for the stimulating and useful comments and suggestions received from guest editor Jiandong Ju, two anonymous reviewers, Adrian Wood and various seminar and conference participants. We are particularly grateful to Kyoji Fukao, Harry Wu and Keiko Ito for collaboration in constructing the data.

Appendix A. The world input–output database

The world input–output database is based on national input–output tables of forty major countries in the world and international trade statistics. It has three distinguishing characteristics compared to other existing multi-regional input–output tables, such as GTAP, the OECD input–output database, and the Asian International input–output tables published by IDE-JETRO.¹⁸ First, the latter provide only a limited number of benchmark year input–output tables whereas WIOD explicitly allows for intertemporal study through the provision of time-series of tables. Second, in contrast to the GTAP and OECD databases, the supply of products is broken down by country and industry of origin. Third, WIOD is the only database that also provides consistent labor and capital input measures.

Basically, a World Input–Output Table (WIOT) is a combination of national input–output tables in which the use of products is broken down according to origin. In contrast to national input–output tables, this information is made explicit in the WIOT. For each country, flows of products are split into domestically produced or imported. In addition, the WIOT shows for imports in which foreign industry the product was produced. This is illustrated by the schematic outline for a WIOT in Fig. A.1. It illustrates a simple WIOT in the case of three regions: countries A and B, and the rest of the world. The rows in the WIOT indicate the use of output from a particular industry in a country. This can be for intermediate use or final use, either domestically or foreign.¹⁹ A fundamental accounting identity is that total use of output in a row (y as defined in Eq. (2)) equals total output of the same industry as indicated by the sum of inputs in the respective column in the left-hand part of the tables. The columns convey information on the technology of production as they indicate the amounts of factor and intermediate inputs needed for production. Intermediate inputs are either sourced from domestic industries or imported and make up the elements $m_{ij}(s,t)$ in Eq. (1). The residual between total output and total intermediate inputs is value added, which measures the direct contribution of domestic factors to output. Final use is indicated in the right part of the table, and this provides information on the f vector defined in Eq. (2).

WIOTs have been specifically constructed to allow for both cross-country and intertemporal comparisons by benchmarking them to the concepts and statistics from the National Accounts, and a common industrial classification (International Standard Industrial Classification revision 3). All national tables are harmonized to conform to a common set of concepts removing idiosyncrasies regarding price concept, treatment of financial services, negatives in the intermediate blocks and ad-hoc columns and rows such as statistical discrepancies. Typically, input–output tables are only available for a limited set of years (e.g. every five year) and once released by the national statistical institute revisions are rare. This compromises the consistency and comparability of these tables over time as statistical systems develop, new methodologies and accounting rules are used, classification schemes change and new data becomes available. For example, Chinese GDP series have been heavily revised when the results of the Economic Census of 2004 became available in 2006, partly due to an underrepresentation of the services industries in previous series (Holz, 2008; Bosworth and Collins, 2008). The published input–output tables, however, have not been revised. This is discussed more in depth in the next section. To remedy this, WIOTs have been constructed on the basis of National Accounts time series and benchmark input–output tables.²⁰ Benchmark tables are linked over time through the use of the most recent National Accounts statistics on final expenditure categories, and gross output and value added by detailed industry. This is done by using a SUT updating method (the SUT-RAS method) as described in Temurshoev and Timmer (2011), which is akin to the well-known bi-proportional (RAS) updating method for input–output tables. This treatment ensures both intercountry and intertemporal consistency of the tables.

A second characteristic of the WIOTs is that the supply of products is broken down by country and industry of origin. This type of information is not available in any input–output table published by national statistical offices. At best, use of a product is split into domestic origin or imports, typically based on the so-called import proportionality assumption, applying a product's economy-wide import share for all use categories. Various studies have been found that this assumption can be rather misleading, in particular at the industry-level as import shares can vary significantly across use category (Feenstra and Jensen, 2012).²¹ To allow for this effect, national SUTs in the WIOD were linked through a classification of bilateral import flows by three end-use categories using detailed international trade statistics. Bilateral import flows of all countries covered in WIOD from all partners in the world at the 6-digit product level of the Harmonized System (HS) were taken from the UN COMTRADE database. Based on the detailed product description, goods were allocated to intermediate use, final consumption use, or investment use. This procedure effectively extends the UN Broad Economic Categories (BEC) classification.²² WIOTs also cover trade in services collected from various international data sources (including OECD, Eurostat, IMF and WTO), checked for consistency and integrated into a bilateral service trade database. The WIOTs are expressed in current US\$ using official exchange

¹⁸ The Asian international input–output table published by IDE-JETRO, has been used for example to study the effects of the US crisis on East Asian production (Kuroiwa and Kuwamori, 2011). GTAP has been used by Koopman et al. (2012) and Johnson and Noguera (2012) to study exports of value added.

¹⁹ In a multi-regional input–output table, final use by a country includes consumption by households, government and non-profit organizations, and gross capital formation, but not exports.

²⁰ In fact, supply and use tables are used if available, rather than input–output tables. Input–output tables are of the industry-by-industry or product-by-product type. Supply and use tables are of a product-by-industry nature and hence provide a better linking with trade data that is typically product-based and employment data that is typically industry-based.

²¹ This depends critically on the level of product detail at which this assumption is applied. Empirical analysis shows that applying it at a lower level of aggregation improves the fit to data constructed on the basis of surveys.

²² Some products, such as complete passenger vehicles, were allocated proportionally to two use categories, in this particular case consumption and investment use.

rates from the IMF to convert tables in national currencies. All tables are expressed in basic prices, which is a price concept that excludes net taxes and trade and transportation margins.²³

References

- Baldwin, Richard E., 2006. Globalisation: The Great Unbundling(s). In: *Globalisation Challenges for Europe*. Office of the Prime Minister of Finland, Europe, Helsinki.
- Banister, Judith, Cook, George, 2011. China's employment and compensation costs in manufacturing through 2008. *Monthly Labor Review*, 39–52.
- Barro, Robert, Lee, Jong-Wha, 2010. A New Data Set of Educational Attainment in the World, 1950–2010. NBER Working Paper No. 15902.
- Bems, Rudolfs, Johnson, Robert C., Yi, Kei-Mu, 2011. Vertical linkages and the collapse of global trade. *American Economic Review Papers and Proceedings* 101 (3), 308–312.
- Bosworth, Barry, Collins, Susan M., 2008. Accounting for growth: comparing China and India. *Journal of Economic Perspectives* 22 (1), 45–66.
- Cao, Jing, Ho, Mun S., Jorgenson, Dale W., Ren, Rouen, Sun, Linlin, Yue, Ximing, 2009. Industrial and aggregate measures of productivity growth in China, 1982–2000. *Review of Income and Wealth* 55 (1), 485–513.
- Chen, Xikang, Cheng, Leonard K., Fung, K.C., Lau, Lawrence J., 2004. The estimation of domestic value added and employment induced by exports: an application to Chinese exports to the United States. In: Presented at the 2005 American Economic Association Meeting, Philadelphia and Working Paper, Stanford University.
- Chen, Xikang, Cheng, Leonard K., Fung, K.C., Lau, Lawrence J., Sung, Yun-Wing, Zhu, Kunfu, Yang, Cuihong, Pei, Jiansuo, Duan, Yuwan, 2012. Domestic value added and employment generated by Chinese exports: a quantitative estimation. *China Economic Review* 23 (4), 850–864.
- de Vries, Gaaitzen J., Erumban, Abdul A., Timmer, Marcel P., Voskoboinikov, Ilya, Wu, Harry X., 2012. Deconstructing the BRICs: structural transformation and aggregate productivity growth. *Journal of Comparative Economics* 40 (2), 211–227.
- Dietzenbacher, Erik, Los, Bart, Stehrer, Robert, Timmer, Marcel P., de Vries, Gaaitzen J., 2013. The construction of world input–output tables in the WIOD project. *Economic Systems Research* 25 (1), 71–98.
- Feenstra, Robert C., Hong, Chang, 2010. China's exports and employment. In: Feenstra, R.C., Wei, Shang-Jin (Eds.), *China's Growing Role in World Trade*. University of Chicago Press, Chapter 5.
- Feenstra, Robert C., Jensen, J. Bradford, 2012. Evaluating Estimates of Materials Offshoring from U.S. Manufacturing. NBER Working Paper No. 17916, March 2012.
- Herrendorf, Berthold, Rogerson, Richard, Valentinyi, Ákos, 2013. Two perspectives on preferences and structural transformation. *American Economic Review* 103 (7), 2752–2789.
- Hirschman, Albert O., 1958. *The Strategy of Economic Development*. Yale University Press, New Haven, Conn..
- Holz, Carsten A., 2008. China's 2004 economic census and 2006 benchmark revision of GDP statistics: more questions than answers? *The China Quarterly* 193, 150–163.
- Johnson, Robert C., Noguera, Guillermo, 2012. Accounting for intermediates: production sharing and trade in value added. *Journal of International Economics* 86 (2), 224–236.
- Koopman, Robert, Wang, Zhi, Wei, Shang-Jin, 2012. Estimating domestic content in exports when processing trade is pervasive. *Journal of Development Economics* 99 (1), 178–189.
- Kuroiwa, Ikuo, Kuroiwa, Kuwamori, Hiroshi, 2011. Impact of the US economic crisis on East Asian economies: production networks and triangular trade through Chinese mainland. *China & World Economy* 19 (6), 1–17.
- Leontief, Wassily W., 1936. Quantitative input–output relations in the economic system of the United States. *Review of Economics and Statistics* 18 (3), 105–125.
- Leontief, Wassily W., 1941. *The Structure of American Economy 1919–1939*. Oxford University Press, New York.
- Levchenko, Andrei A., Zhang, Jing, 2012. Comparative advantage and the welfare impact of European integration. *Economic Policy* 27 (72), 567–602.
- Los, Bart, Timmer, Marcel P., de Vries, Gaaitzen J., 2014. How global are global value chains? A new approach to measure international fragmentation. *Journal of Regional Science*. <http://dx.doi.org/10.1111/jors.12121>, forthcoming.
- Ma, Hong, Wang, Zhi, Zhu, Kunfu, 2013. Domestic value-added in China's exports and its distribution by firm ownership. In: Paper Presented at the International Conference on Global Value Chains and Structural Adjustments, Tsinghua University.
- Ma, Yue, Tang, Heiwai, Zhang, Yifan, 2014. Factor intensity, product switching, and productivity: evidence from Chinese exporters. *Journal of International Economics* 92 (2), 349–362.
- Manova, Kalina, Yu, Zhihong, 2014. Firms and Credit Constraints along the Global Value Chain: Processing Trade in China. NBER Working paper w18561.
- Miller, Ronald E., Blair, Peter D., 2009. *Input–Output Analysis: Foundations and Extensions*. Cambridge University Press.
- National Bureau of Statistics of China, 1995, 1999, 2006, 2009. *China Statistical Yearbook (Zhongguo tongli nianjian)*. China Statistical Publishing House, Beijing.
- National Bureau of Statistics, 1995, 1999, 2006, 2009. *Input–Output Tables of China 1992, 1997, 2002, 2007*. China Statistics Press, Beijing.
- Organisation for Economic Cooperation and Development, 2014. *OECD National Account Statistics*. OECD, Paris.
- Pei, Jiansuo, Oosterhaven, Jan, Dietzenbacher, Erik, 2012. How much do exports contribute to China's income growth? *Economic Systems Research* 24 (3), 275–298.
- Temurshoev, Umed, Timmer, Marcel P., 2011. Joint estimation of supply and use tables. *Papers in Regional Science* 60 (4), 863–882.
- Timmer, Marcel P. (Ed.), 2012. *The World Input–Output Database (WIOD): Contents, Sources, and Methods*. WIOD working paper nr. 10, www.wiod.org.
- Timmer, Marcel P., Los, Bart, Stehrer, Robert, de Vries, Gaaitzen J., 2013. Fragmentation, incomes and jobs: an analysis of European competitiveness. *Economic Policy* 28, 613–661.
- UNESCO Institute for Statistics, 2007. *World Education Indicators Programme*.
- Upward, Richard, Wang, Zheng, Zheng, Jinghai, 2013. Weighing China's export basket: the domestic content of technology intensity of Chinese exports. *Journal of Comparative Economics* 41 (2), 527–543.
- World Bank, 2012. *Jobs*. World Development Report 2013. IBRD/World Bank, Washington DC.
- Wu, Harry X., 2011. Accounting for China's Growth in 1952–2008. RIETI Discussion Paper, 11-E-003.
- Wu, Harry X., Yue, Ximing, 2010. Accounting for labor input in Chinese industry, 1949–2005. In: Paper Presented at the 31st General Conference of the International Association for Research in Income and Wealth, August 2010.
- Zhao, Hong, 2010. Differences between GDP accounts and IO accounts in China's statistical system. China, National Bureau of Statistics, working paper.

²³ Trade and transport margins are allocated as output to the respective trade and transport industries.