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Domestic Segment of Global Value Chains in China under State Capitalism[☆]

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ABSTRACT

This paper studies the relationship between the changing domestic segment of global value chains and the return of state capitalism in China. To this end, we propose a method to estimate an extended input-output (IO) table that tracks inter-sector transactions between different types of firms in a domestic economy. The method is an application of constrained optimization, which relies on basic information from a country's national IO table, as well as sector- and firm-level data. We also propose a way to construct bootstrapped standard errors for any global value chain (GVC) measures estimated from the extended IO tables. We then use the extended IO table to study the domestic segment of GVC in China. We find that, not only is state-owned enterprises' (SOEs) domestic value-added to gross exports ratio much higher than those of other firms, but it also increased significantly from 1.2 in 2007 to 1.7 in 2010. Our findings suggest that, even after years of privatization, SOEs still play an important role in shaping China's exports.

1. Introduction

China's unprecedented economic growth in the past three decades is often attributed to its market-oriented reforms (Branstetter and Lardy, 2006). The Chinese government actively sought to privatize state-owned enterprises (SOEs), which contributed to the country's significant productivity increases and economic growth (Brandt, Van Biesebroeck, Zhang, 2012; Zhu, 2012).[1]

While the role of SOEs in the Chinese economy has been diminishing in the past few decades (Lardy, 2014), recent evidence points to a resurgence in the role of SOEs in the economy, especially because of the monopoly power they command in key upstream sectors,

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[1] The 15th Congress of the Chinese Communist Party in 1997 marked the watershed of China's economic reforms. The Congress formally sanctioned ownership reforms of the SOEs and also legalized the development of private enterprises.

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such as banking, electricity, and hydrocarbons.[2] This phenomenon is not unique to China. A recent OECD study reveals that SOEs still command a significant share of large emerging markets, including Brazil, Russia, and India, in terms of both sales and assets (Kowalski et al., 2013).

This paper seeks to document whether the changing domestic segment of global value chains (GVC) contributed to the resurgence of state capitalism in China. We study the question from the perspective of international trade, by analyzing SOEs' contribution to China's domestic value added (DVA) in exports. More specifically, we answer the following questions: In which sectors did SOEs still possess a dominant presence? How did the changing distribution of SOEs across sectors along the GVC shape other firms' participation in trade? How might downstream firms' increasing exports help explain the revived dominance of SOEs in China?

To answer these questions, we first develop a framework to use firm-level data to expand a standard input-output (IO) table into a more detailed account that reports inter-sector firm transactions within the economy. Our method belongs to the large class of quadratic optimization models,[3] which feature a minimization of a quadratic penalty function with arguments equal to the values of the extended IO table, subject to a series of accounting identities and adding-up constraints based on official statistics (e.g., industry-level exports and imports). The method only requires a minimal set of information: (1) a country's national IO table, (2) firm balance-sheet data, and (3) trade statistics by firm group and sector. As an additional literature contribution, we propose a way to compute the standard errors for the estimates of the extended IO table, using samples bootstrapped from the underlying micro data.

We implement the optimization model using China's IO tables for 2007 and 2010, along with 2008 census data for both manufacturing and service firms.[4] Firms are categorized into four groups based on their equity ownership structure and size: state-owned, foreign, large private, and small and medium-sized private (SMEs). We then estimate the value of the IO transactions between firm group pairs in the extended tables using our proposed constrained quadratic optimization method. Based on these estimates, we quantify the contributions of different domestic IO channels to Chinese DVA in exports.[5]

We find that, in China, SOEs' DVA in exports is significantly larger than the value of their gross exports. This contrasts the conventional view that Chinese exports are associated with a lower domestic value added to gross exports ratio (DVAR) (Chen et al., 2012; Koopman et al., 2008). Specifically, the DVAR of SOEs is estimated to be 1.7 in 2010, up 47% from 1.2 in 2007. Among private firms, large firms' DVA ratio is around 0.7 while that of SMEs is above 1 for both years (1 and 1.3 in 2007 and 2010, respectively). Foreign firms' DVAR hovers around 0.35 for both years.[6] In sum, SOEs' and SMEs' DVAR's are much larger than those of other types of firms, and that of aggregate exports.

To address the concern that our estimates can be imprecise or sensitive to the initial conditions and constraints imposed in the optimization, we propose a way to construct bootstrapped standard errors for all estimated GVC measures using extended IO tables. This procedure involves simulating thousands of IO tables using constraints and initial values constructed with data from randomly drawn firm samples. The bootstrapped standard errors for our estimates show that the estimation results in general are robust to the choices of initial values in the objective function and linear constraints.[7]

Equipped with the extended IO tables, we study the pattern of domestic trade transactions between different types of firms in China. We find that indirect exports (exports through other firms) accounted for about 80% of SOEs' DVA in both 2007 and 2010. In fact, about 40% of their DVA was indirect exports through SME and foreign firms. This suggests that despite their relatively small engagement in direct exports, SOEs' actual participation in, and therefore impact on, China's exports have been significant. Similarly, large private firms and SMEs also have a large share of indirect exports in DVA. Different from all other firm groups, foreign firms tend to have significantly lower DVA ratios, both direct and indirect.

We also use the extended IO tables to analyze the reasons behind the high and rising indirect export participation by both SOEs and SMEs. Focusing on the sectoral composition of indirect exports by firm group, we find that SOEs' indirect exports relate to their prevalence, measured by output and export shares, in upstream and mostly non-tradable sectors, such as banking, mining, energy, and the supply of electricity, gas and water. We also find that SOEs are, on average, more upstream in GVC *within* sectors, based on the "upstreamness" measures proposed by Antràs et al. (2012) and Fally, 2012. These patterns are outcomes of the unique sequence of China's privatization across sectors, which started from the downstream, competitive sectors of the supply chains in the late 1990s but ended without the privatization of upstream, monopolistic sectors. Given that many upstream sector firms, especially those in the

[2] The phrase *guo jin min tui,* which literally means "the state advances, the private sector retreats", has become viral in social media and the academic community. For instance, China National Petroleum Corporation and China Mobile together made profits of $33 billion in 2009, more than the country's 500 most profitable private companies combined (*Economist* "The rise of state capitalism", published on Jan 21, 2012). More privatization in upstream sectors, in particular the banking sector, has been proposed, but the progress has been slow.

[3] In mathematical terms, our method belongs to a class of methods called constraint matrix balancing. Another class of matrix balancing is bi-proportional scaling, which is based on adjusting the initial matrix by multiplying its row and column by positive constants until the matrix is balanced (Stone et al., 1963). The alternative strategy is usually referred to as RAS.

[4] Previous research has extended an IO table to take into account the differences between processing and non-processing trade in China and Mexico (e.g., Koopman, Wang, and Wei, 2014).

[5] The same approach has been used to split a national IO table for China into regional IO tables (Koopman et al., 2014). These regional IO tables can be used to assess the effects of trade liberalization on intra-national trade and regional income disparity. See Tombe and Zhu (2015) for such an analysis for China.

[6] These results contrast with the findings in developed countries, such as the United States, where large firms tend to have lower DVA.

[7] The estimates can become less precise if the underlying firm observations used to construct those conditions are more dispersed. Naturally, when we reduce the number of observations in each firm category by considering more dimensions of firm characteristics, the standard errors of our estimates will increase.

utilities sector, do not export directly, their exports are largely indirect and embedded as value added in other firms' exports. As such, firms in upstream sectors or in the relatively upstream position within a sector tend to have a high DVAR in exports. The prevalence of SOEs in upstream sectors or in upstream positions within a sector, thus, explains their relatively higher DVA ratio.

SMEs also have high DVA and indirect export ratios, but for very different reasons from those for SOEs. SMEs are on average more downstream along GVC within sectors. Possibly because of high fixed costs of exporting that are difficult to overcome, they have greater propensity to sell intermediate inputs and services to direct exporters, including trade intermediaries. These analyses of the ownership structure of GVC inside China can offer important insights for understanding the country's past and future economic growth.[8]

Despite this paper's focus on China, our estimation framework is general enough to be applied to a wide range of topics in trade and economic geography, such as the propagation of demand or supply shocks across sectors and regions within an economy, the benefits for SME to participate in GVC even without direct exports, and the distribution of gains from trade across sectors and regions.

This paper makes several contributions to the literature. First, it adds to the growing literature on the measurement of global production fragmentation using IO tables (e.g., Hummels et al., 2001; Koopman, Wang, and Wei, 2014; Johnson and Noguera, 2016), which has focused on the shares of domestic versus foreign value added in international trade while paying relatively little attention to the composition and dynamics of the domestic segment of GVC. More specifically, relatively few studies have explored how international trade shapes domestic trade between firms and industries.[9] The two notable exceptions are Koopman et al., 2012 and Ma et al., 2015.[10] This paper improves upon existing studies on several fronts. First and foremost, on the methodological front, we show how to compute standard errors for all estimates in our extended IO table and the related estimates. Second, our firm census data set covers many more firms, including all SMEs. Third, our research focus is vastly different. Koopman et al., 2012 focus on correcting the upward bias in the estimated domestic content in exports when processing trade is pervasive. Ma et al., 2015, on the other hand, focus on the respective contributions of foreign and domestic exporters to China's GDP. This paper offers a more detailed account of the domestic segment of GVC, and specifically highlights the much higher DVAR of SOEs, a unique aspect of the domestic segment of GVC in China.

Relating to the literature on trade in value-added, our approach extends the IO table approach to take firm heterogeneity in international trade—an important aspect emphasized by the recent trade literature—into account.[11] Firms differ substantially in export intensity, import intensity, and participation in GVC. Other characteristics such as ownership structure (domestic/foreign, private/public), location, and size can also directly affect the way firms respond to trade liberalization and other economic shocks. Aggregate IO tables offer no information about the underlying firm heterogeneity. Unless buyer-seller linked data are available, which represents a recent phenomenon (e.g., Tintelnot et al., 2018), reducing the aggregation biases in GVC measures computed using aggregate IO tables is not feasible.[12] By proposing a method to extend a typical IO table, our paper offers a solution to reduce the aggregation biases arising from specific aspects of firm heterogeneity.

This paper also contributes to the literature on the determinants of firms' indirect exporting. Research in international trade shows that only a small fraction of firms, typically the more productive ones that expect enough export profits to overcome fixed exporting costs, participate in international trade directly (e.g., Bernard et al., 2015). Many non-exporters may engage in trade indirectly, through intermediaries and by providing intermediate inputs and services to direct exporters. While the literature on trade intermediaries has received some attention (e.g., Bernard et al., 2010 and Ahn et al., 2011), how much value added is generated from exporting indirectly though other firms has not received the attention it deserves, partly due to the lack of data.[13] Our paper provides a method that combines firm-level and industry-level data to quantify indirect export volumes, and the channels through which they are created.

[8] For instance, to the extent that SOEs are less productive than non-state firms (e.g., Zhu, 2012), a deeper privatization of SOEs or lower entry barriers in upstream industries may increase the efficiency of direct exporters in the downstream, which in turn increases the speed of upgrading of Chinese exporters' along GVC. The conventional view is that China's export growth is largely driven by the dynamic labor-intensive private sector, especially the foreign-dominated processing trade sector. Our findings add to this conventional view by showing that SOEs, through their protected position in the upstream, have been playing an important role in shaping Chinese export patterns and performance.

[9] Furusawa et al. (2019) study the effects of firms' offshoring on a country's domestic production network.

[10] Both studies also employ constrained optimization to estimate the inter-sector transactions between different types of firms (processing and non-processing firms in the former while foreign and domestic firms in the latter) in China.

[11] This literature started with Bernard et al. (2003) and Melitz (2003). See Bernard el al. (2015) for a comprehensive review of both the theoretical and empirical literatures on firms and trade.

[12] A widely recognized drawback of using IO tables to measure DVA is the assumption that firms within an industry use the same technology for production. Proportionality assumptions are often made in order to distribute imports into different final uses and different source countries, as information on bilateral trade between suppliers and users is generally not available at the country-industry level. These assumptions have been shown to lead to substantial biases in the estimation of countries' value added, factor content of trade, and our general inference of the impact of trade on countries' macro-economy (e.g., Puzzello, 2012). For instance, De La Cruz et al. (2010) and Koopman, Wang and Wei (2012) show that by allowing different imported material intensities for processing and non-processing exporters, the estimated foreign value added ratio in aggregate exports from both China and Mexico increases significantly. Relatedly, Kee and Tang (2016) show that a country's domestic content in exports computed using IO tables are generally biased downward. It is because when constructing IO tables, statistical agencies rely on large firms, which tend to have higher import intensities.

[13] A notable exception is the report by the USITC, 2010, who also uses the constrained optimization methodology to estimate the contribution of small and medium enterprise (SME) to US exports. The report finds that SME's total contribution to U.S. exports increased from less than 28% to 41% in 2007, when the value of intermediates supplied by SME to exporting firms is taken into account.

On the methodological front, our paper contributes to previous attempts to cast the estimation of unknown values in IO tables as a constrained matrix balancing problem (van der Ploeg, 1988, Nagurney and Robinson, 1989, Bartholdy, 1991). It also adds to the information theory literature on estimating inter-region transactions using regional economic statistics and input-output accounts (Batten, 1982; Batten and Martellato, 1985, Canning and Wang, 2005). In particular, our paper is closely related to Golan, Judge and Robinson (1994), who also pose the estimation as an optimization problem with a nonlinear criterion objective function and multiple linear constraints.

Finally, this paper adds to the broad literature on the progress of privatization and the role of SOEs in the Chinese economy (e.g., Brandt et al, 2012; Zhu, 2012; Hsieh and Song, 2015).[14] As opposed to existing studies, we focus on quantifying the trade pattern of SOEs, and how it affects and is affected by trade among other firms.

The rest of this paper is organized as follows: Section 2 develops the conceptual framework for our estimation. Section 3 introduces the optimization model. Section 4 describes the data sources and the initial conditions of the optimization procedures. Section 5 explains how conventional bootstrapping can be combined with our method to compute standard errors for our estimates. Section 6 applies the method by studying the estimated DVA for different firm groups in China, focusing on SOEs; and Section 7 concludes.

2. Conceptual Framework

This section first defines the concepts of direct and indirect DVA, before introducing the structure of an extended IO table. We will then show how to decompose indirect exports into their various domestic IO channels based on firm groups, and specify the variables that cannot be computed using information from standard IO tables, and need to be estimated. Details about the estimation will be discussed in Section 3.

2.1. The definition of Domestic Value Added in Exports

The standard domestic IO table reports the value of intermediate inputs sold by one industry to another in an economy. An IO economy with N industries must satisfy the following equation:

$$\mathbf{u} = \mathbf{A_V} + \mathbf{uA^d} + \mathbf{uA^m}, \tag{1}$$

where $\mathbf{u}$ is a $1\times$N unit vector, $\mathbf{A_V} = [\frac{\mathbf{v_j}}{\mathbf{x_j}}]$ is a $1\times$N vector of each industry's ratio of value added (v) to gross output (x); $\mathbf{A^d} = [a_{ij}^D] = [\frac{z_{ij}^D}{x_j}]$ is an N$\times$N matrix of the coefficients of direct input of domestic goods and services (z_{ij}^D); $\mathbf{A^m} = [\frac{z_{ij}^F}{x_j}]$ is an an N$\times$N matrix of direct input of imported goods and services (z_{ij}^F).

Taking $\mathbf{uA^d}$ to the left hand side of eq. (2) and rearranging it yields

$$\mathbf{u} = \mathbf{A_V}(\mathbf{I} - \mathbf{A^d})^{-1} + \mathbf{uA^m}(\mathbf{I} - \mathbf{A^d})^{-1} = \mathbf{A_V B} + \mathbf{uA^m B}, \tag{2}$$

where $\mathbf{B} = (\mathbf{I} - \mathbf{A^d})^{-1}$ is the well-known Leontief inverse matrix.[15] which can be used to compute the total gross output needed in the domestic economy to produce one dollar of exports. The value added created by the direct exporters is called *direct* DVA. To produce direct DVA, intermediate inputs have to be used, which in turn generate additional value added for firms in the upstream part of the supply chains. This process of value-added creation continues infinitely in the domestic IO network. The total DVA induced by one dollar of exports is thus equal to the sum of direct and all rounds of indirect DVA created.

Post-multiplying both sides of eq. (2) by the diagonal matrix with elements equal to exports from each sector $\hat{\mathbf{E}}$, yields

$$\mathbf{u}\hat{\mathbf{E}} = \mathbf{u}\hat{\mathbf{A}}_\mathbf{V}\mathbf{B}\hat{\mathbf{E}} + \mathbf{uA^m B}\hat{\mathbf{E}}, \tag{3}$$

where $\hat{\mathbf{A}}_\mathbf{V}$ is a N $\times$ N diagonal matrix of $\mathbf{A_V}$.

Eq. (3) states that the country's total gross exports $\mathbf{u}\hat{\mathbf{E}}$, a $1\times$N row vector, can be decomposed into DVA in exports $\mathbf{u}\hat{\mathbf{A}}_\mathbf{V}\mathbf{B}\hat{\mathbf{E}}$ (either used directly for production of exported goods and services, or indirectly by firms that supply inputs to exporters), and imported materials embedded in exports $\mathbf{uA^m B}\hat{\mathbf{E}}$, which include imported intermediates used directly by exporters or embodied in other domestic intermediates used by them.

The first term on the right hand side of eq. (3), $\mathbf{u}\hat{\mathbf{A}}_\mathbf{V}\mathbf{B}\hat{\mathbf{E}}$, is the key to our quantification of DVA. Specifically, $\hat{\mathbf{A}}_\mathbf{V}\mathbf{B}\hat{\mathbf{E}}$ is a N$\times$N matrix, with each element representing the source (sector of origin) and the channel (through which sector) of DVA. Depending on the research question, one can aggregate $\hat{\mathbf{A}}_\mathbf{V}\mathbf{B}\hat{\mathbf{E}}$ vertically or horizontally to estimate DVA. If the goal is to decompose DVA into its using (downstream) sectors, we can use the forward-linkage approach by summing up the elements of $\hat{\mathbf{A}}_\mathbf{V}\mathbf{B}\hat{\mathbf{E}}$ horizontally along each row. If the goal is to measure DVA embodied in gross exports from different sourcing sectors, we can adopt the backward-linkage

[14] Research on the effects of the unique sequence of privatization across sectors has been sparse. Notable exceptions include the recent theoretical work by Song et al. (2011) and Wang et al., 2012, who both highlight and rationalize the high profitability of SOEs.

[15] Similar to **A, B** is a high dimensional matrix that is composed of 6 x 6 block matrices. Each block matrix, $\mathbf{B}^{g1,\ g2}$, is a 42$\times$42 matrix with elements equal to the total requirement coefficients, representing the amount of required gross output by firm group g1 for a one unit increase in domestic final demand or exports.

approach by summing up the elements of $\hat{\mathbf{A}}_{\mathbf{V}}\mathbf{B}\hat{\mathbf{E}}$ vertically in each column.[16]

To implement the forward-linkage approach so that we can trace the final use of value added created by the primary factors of production, we post-multiply both sides of eq. (3) by a N × 1 unit vector, $\boldsymbol{\mu}$. This operation sums up the value added horizontally to obtain DVA at the sector level. Formally, the DVA based on the forward-linkage approach is

$$\mathbf{DVA}_{\mathbf{fw}} = \mathbf{DVA}\mu = \hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}}\mu + \hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B} - \mathbf{I})\hat{\mathbf{E}}\mu, \tag{4}$$

where $\mathbf{DVA}_{\mathbf{fw}}$ is a N × 1 column vector.

To implement the backward-linkage approach, we expand the N × N DVA matrix as

$$\mathbf{DVA} = \hat{\mathbf{A}}_{\mathbf{V}}\mathbf{B}\hat{\mathbf{E}} = \hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}} + \hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B} - \mathbf{I})\hat{\mathbf{E}}. \tag{5}$$

On the right hand side of eq. (5), the first term, $\hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}}$, captures direct DVA, while the second term, $\hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B} - \mathbf{I})\hat{\mathbf{E}}$, represents indirect DVA. The elements along the diagonal of $\hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B} - \mathbf{I})\hat{\mathbf{E}}$ represent indirect exports in the same sector, while its off-diagonal elements reveal indirect exports through other sectors.

2.2. Splitting a Domestic IO Table based on Firm Characteristics

Given our focus, we split the 42-sector non-competitive IO table of China into 6 sub-accounts,[17] based on 3 ownership types: State (S), Foreign (F), or Private (P); and 2 size categories: large and small-and-medium-sized. With a total of 252 firm-group-sector combinations (3 ownership types × 2 firm sizes × 42 sectors), we need to estimate 252 × 252 (including the within-firm-group transactions) unknown values of domestic transactions. From now on, matrices and vectors will be presented in boldface.

Figure 1 illustrates the extended IO table. Matrices *Z, Y, E, X,* and *M* represent, respectively, intermediate inputs, domestic final demand, exports, total output, and imports. We use a two-alphabet superscript to denote one of the 6 firm groups. The first alphabet denotes ownership type (S, F, or P) while the second subscript denotes firm size (L or S). A combination of an ownership type and a size category gives us a firm group, $g \in$ {SL, SS, FL, FS, PL, PS}. Subscripts *i* and *j* represent supplying and using sectors.

The last three rows in Figure 1 report imported intermediate inputs (Z^F), value added (*V*) and total gross output (*X*), respectively. The last three columns are respectively domestic final use, exports, and total gross output. The remaining part of the extended IO table, which we aim to estimate, is a 6 × 6 block of square matrices, each has a dimension of 42 × 42. For example, $\mathbf{Z}^{\mathbf{SL,SL}}$ in row (1) and column (1) is a 42 × 42 matrix, with an element in row *i* and column *j*, $z_{ij}^{SL,SL}$, representing output produced by large SOEs in sector *i* used as intermediate inputs by other large SOEs in sector *j*. Moving horizontally along row (1), each matrix, $\mathbf{Z}^{\mathbf{SL,g}}$, is a 42 × 42 matrix with an element $z_{ij}^{SL,g}$ in row *i* and column *j* representing output that is still produced by large SOEs in sector *i* but is used as intermediate inputs by group-*g* firms in sector *j*. Similarly, when moving down vertically within a column, each entry is a 42 × 42 matrix $\mathbf{Z}^{\mathbf{g1,g2}}$ with elements $z_{ij}^{g1,g2}$ representing output produced by group-*g1* firms in sector *i*, sold as intermediate inputs to group-*g2* firms in sector *j*.

Row (7) of Figure 1 describes the various uses of imported goods. The first 6 entries are 42 × 42 matrices, $\mathbf{Z}^{\mathbf{F,\ g2}}$, with element, $z_{ij}^{F,g2}$, representing imported product *i* used as intermediate inputs by group-g2 firms in sector *j*. The 7th entry, $\mathbf{Y}^{\mathbf{F}}$, is a 42 × 1 vector of imports for final consumption and capital formation by sector. The last entry in row 7, **M**, is a 42 × 1 vector of total imports by sector. Rows 8 and 9 contain the matrices of sectoral value added and gross output of the 6 different firm groups, respectively.[18]

We can redefine the input-output matrices in the extended IO table as follows

$$\mathbf{A}^{\mathbf{g1,g2}} = [a_{ij}^{g1,g2}] = \left[\frac{z_{ij}^{g1,g2}}{x_j^{g2}}\right]$$

$$\text{and} \quad \mathbf{A}^{\mathbf{F,g2}} = [a_{ij}^{F,g2}] = \left[\frac{z_{ij}^{F,g2}}{x_j^{g2}}\right],$$

where *i* and *j* stand for the row and column subscripts, respectively. $\mathbf{A}^{\mathbf{g1,\ g2}}$ is a 42 × 42 block matrix, with each element being an IO coefficient representing the amount of output produced by firms in group *g1* used as intermediate inputs in the production of one unit of output by group-*g2* firms. *g1* and *g2* can each be one of the six firm groups.

Stacking $\mathbf{A}^{\mathbf{g1,\ g2}}$ and $\mathbf{A}^{\mathbf{F,\ g2}}$ up in a mega matrix following the structure of the IO table outlined in Figure 1 yields

[16] See Wang et al., 2013 for a more detailed discussion on forward- and backward-linkage approaches to measure value-added exports.

[17] The non-competitive IO table assumes that imported and domestic products are not substitutable, in contrast to the standard IO table that assumes perfect substitutability between imported and domestic products. When competitive IO tables are used, only one set of IO coefficients are needed. The underlying Leontief or linear production functions assumed in either approach have their obvious drawbacks. However, we consider our approach, which permits different IO coefficients on imported and domestic inputs across sector-pairs, to be more suitable for the purpose of our study.

[18] For example, in the first column in Row 8, $\mathbf{V}^{\mathbf{SL}}$ is a 1x42 row vector that has element *i* equal to the direct value added of large SOEs in sector *i* (cost of production factors).

				Intermediate use								
				SL	SS	FL	FS	PL	PS	Domestic Final Use	Exports	Gross Output
				(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Dimension	N	N	N	N	N	N	1	1	1
Domestic Intermediates	(1)	SL	N	$Z^{SL,SL}$	$Z^{SL,SS}$	$Z^{SL,FL}$	$Z^{SL,FS}$	$Z^{SL,PL}$	$Z^{SL,PS}$	Y^{SL}	E^{SL}	X^{SL}
	(2)	SS	N	$Z^{SS,SL}$	$Z^{SS,SS}$	$Z^{SS,FL}$	$Z^{SS,FS}$	$Z^{SS,PL}$	$Z^{SS,PS}$	Y^{SS}	E^{SS}	X^{SS}
	(3)	FL	N	$Z^{FL,SL}$	$Z^{FL,SS}$	$Z^{FL,FL}$	$Z^{FL,FS}$	$Z^{FL,PL}$	$Z^{FL,PS}$	Y^{FL}	E^{FL}	X^{FL}
	(4)	FS	N	$Z^{FS,SL}$	$Z^{FS,SS}$	$Z^{FS,FL}$	$Z^{FS,FS}$	$Z^{FS,PL}$	$Z^{FS,PS}$	Y^{FS}	E^{FS}	X^{FS}
	(5)	PL	N	$Z^{PL,SL}$	$Z^{PL,SS}$	$Z^{PL,FL}$	$Z^{PL,FS}$	$Z^{PL,PL}$	$Z^{PL,PS}$	Y^{PL}	E^{PL}	X^{PL}
	(6)	PS	N	$Z^{PS,SL}$	$Z^{PS,SS}$	$Z^{PS,FL}$	$Z^{PS,FS}$	$Z^{PS,PL}$	$Z^{PS,PS}$	Y^{PS}	E^{PS}	X^{PS}
Imported Intermediates	(7)	Abroad	N	$Z^{F,SL}$	$Z^{F,SS}$	$Z^{F,FL}$	$Z^{F,FS}$	$Z^{F,PL}$	$Z^{F,PS}$	Y^{F}		M
Value-added	(8)		N	V^{SL}	V^{SS}	V^{FL}	V^{FS}	V^{PL}	V^{PS}			
Gross Output	(9)		1	$(X^{SL})^T$	$(X^{SS})^T$	$(X^{FL})^T$	$(X^{FS})^T$	$(X^{PL})^T$	$(X^{PS})^T$			

Note: SL, SS, FL, FS, PL, and PS stand for large SOEs, small SOEs, large foreign, small foreign, large private, and small private firms, respectively. Dimension equals to the number of elements in either the row or column of each matrix.

Figure 1. Input-Output Table with Separate Transactions by Firm Ownership Type and Size.

$$\mathbf{A} = \begin{bmatrix} \mathbf{A^d} \\ - - - \\ \mathbf{A^m} \end{bmatrix},$$

where

$$\mathbf{A^d} = \begin{bmatrix} \mathbf{A}^{\mathbf{SL,SL}} & \mathbf{A}^{\mathbf{SL,SS}} & \mathbf{A}^{\mathbf{SL,FL}} & \mathbf{A}^{\mathbf{SL,FS}} & \mathbf{A}^{\mathbf{SL,PL}} & \mathbf{A}^{\mathbf{SL,PS}} \\ \mathbf{A}^{\mathbf{SS,SL}} & \mathbf{A}^{\mathbf{SS,SS}} & \mathbf{A}^{\mathbf{SS,FL}} & \mathbf{A}^{\mathbf{SS,FS}} & \mathbf{A}^{\mathbf{SS,PL}} & \mathbf{A}^{\mathbf{SS,PS}} \\ \mathbf{A}^{\mathbf{FL,SL}} & \mathbf{A}^{\mathbf{FL,SS}} & \mathbf{A}^{\mathbf{FL,FL}} & \mathbf{A}^{\mathbf{FL,FS}} & \mathbf{A}^{\mathbf{FL,PL}} & \mathbf{A}^{\mathbf{FL,PS}} \\ \mathbf{A}^{\mathbf{FS,SL}} & \mathbf{A}^{\mathbf{FS,SS}} & \mathbf{A}^{\mathbf{FS,FL}} & \mathbf{A}^{\mathbf{FS,FS}} & \mathbf{A}^{\mathbf{FS,PL}} & \mathbf{A}^{\mathbf{FS,PS}} \\ \mathbf{A}^{\mathbf{PL,SL}} & \mathbf{A}^{\mathbf{PL,SS}} & \mathbf{A}^{\mathbf{PL,FL}} & \mathbf{A}^{\mathbf{PL,FS}} & \mathbf{A}^{\mathbf{PL,PL}} & \mathbf{A}^{\mathbf{PL,PS}} \\ \mathbf{A}^{\mathbf{PS,SL}} & \mathbf{A}^{\mathbf{PS,SS}} & \mathbf{A}^{\mathbf{PS,FL}} & \mathbf{A}^{\mathbf{PS,FS}} & \mathbf{A}^{\mathbf{PS,PL}} & \mathbf{A}^{\mathbf{PS,PS}} \end{bmatrix}, \tag{6}$$

and $\mathbf{A^m} = [\mathbf{A}^{\mathbf{F,SL}} \;\; \mathbf{A}^{\mathbf{F,SS}} \;\; \mathbf{A}^{\mathbf{F,FL}} \;\; \mathbf{A}^{\mathbf{F,FS}} \;\; \mathbf{A}^{\mathbf{F,PL}} \;\; \mathbf{A}^{\mathbf{F,PS}}]$. Notice that $\mathbf{A}$ has 294 (7×42) rows and 252 (6×42) columns.

Let us also define $\mathbf{A}_V^{g1} = [\frac{v_j^{g1}}{x_j^{g1}}]$ as a 1×42 vector of direct value added coefficients for firm group *g1* where $\frac{v_j^{g1}}{x_j^{g1}}$ is the ratio of value added to output by group-*g1* firms producing in sector *j*. Putting them horizontally into a vector yields $\mathbf{A_V} = [\mathbf{A}_V^{SL}, \mathbf{A}_V^{SS}, \mathbf{A}_V^{FL}, \mathbf{A}_V^{FS}, \mathbf{A}_V^{PL}, \mathbf{A}_V^{PS}]$, a 1×252 row vector covering all sectors and firm groups.

Eq. (6) can be further decomposed into its various channels through which DVA is created. The first row in $\hat{\mathbf{A}}_\mathbf{V}\hat{\mathbf{E}}\mu$ represents the direct DVA from large SOEs (SL). The first row of the second term, $\hat{\mathbf{A}}_\mathbf{V}(\mathbf{B} - \mathbf{I})\hat{\mathbf{E}}\mu$, is the sum of 6 terms as follows:

$$\hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}(\mathbf{B}^{\mathbf{SL,SL}} - \mathbf{I})\hat{\mathbf{E}}^{\mathbf{SL}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,SS}}\hat{\mathbf{E}}^{\mathbf{SS}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,FL}}\hat{\mathbf{E}}^{\mathbf{FL}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,FS}}\hat{\mathbf{E}}^{\mathbf{FS}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,PL}}\hat{\mathbf{E}}^{\mathbf{PL}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,PS}}\hat{\mathbf{E}}^{\mathbf{PS}}\tilde{\mu}$$

$$\hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}(\mathbf{B}^{\mathbf{SL,SL}} - \mathbf{I})\hat{\mathbf{E}}^{\mathbf{SL}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,SS}}\hat{\mathbf{E}}^{\mathbf{SS}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,FL}}\hat{\mathbf{E}}^{\mathbf{FL}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,FS}}\hat{\mathbf{E}}^{\mathbf{FS}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,PL}}\hat{\mathbf{E}}^{\mathbf{PL}}\tilde{\mu} + \hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,PS}}\hat{\mathbf{E}}^{\mathbf{PS}}\tilde{\mu}, \tag{7}$$

where $\tilde{\mu}$ is a 42×1 column vector. $\hat{A}_\mathbf{V}^{\mathbf{SL}}(\mathbf{B}^{\mathbf{SL,SL}} - \mathbf{I})\hat{\mathbf{E}}^{\mathbf{SL}}\tilde{\mu}$ is indirect DVA via large SOEs, while $\hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,SS}}\hat{\mathbf{E}}^{\mathbf{SS}}\tilde{\mu}$, $\hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,FL}}\hat{\mathbf{E}}^{\mathbf{FL}}\tilde{\mu}$, $\hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,FS}}\hat{\mathbf{E}}^{\mathbf{FS}}\tilde{\mu}$, $\hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,PL}}\hat{\mathbf{E}}^{\mathbf{PL}}\tilde{\mu}$, and $\hat{\mathbf{A}}_\mathbf{V}^{\mathbf{SL}}\mathbf{B}^{\mathbf{SL,PS}}\hat{\mathbf{E}}^{\mathbf{PS}}\tilde{\mu}$ represent large SOEs' indirect DVA via small SOEs, large foreign, small foreign, large private, and SMEs' exports, respectively. Other rows in eq. (7) can be interpreted similarly for other firm groups. Eq. (7) thus provides detailed information about the volume of direct and indirect DVA, as well as the IO channels through which firm groups' indirect exports are generated.

3. Estimation Method

We now use eqs. (4), (5), and (7) to study the direct and indirect DVA by firm group at the aggregate and sector levels. Since the conventional IO table from all statistical agencies we are aware of reports only inter-sector transactions, but not the block matrices by firm group, we need to develop a method to estimate the sub-accounts described in Figure 1.

Before describing our estimation methods, let us revisit what information is available from a standard IO table. At the sector level, a standard national IO table contains the following information:

x_i	gross output of sector i;
z_{ij}^D	domestic goods from sector i used as intermediate inputs in sector j;
z_{ij}^F	imported goods from sector i used as intermediate inputs in sector j;
v_j	direct value added in sector j;
e_i	total exports of sector i goods;
m_i	total imports of sector i goods;
y_i^D	total domestic final-good demand for sector i goods (excluding exports);
y_i^F	total final-good demand for imported goods i.

This information from a national IO table will be used to construct the adding-up constraints in our optimization, which restrict the estimates of our extended IO table to add up to the values in the original IO table. To estimate our extended IO table with 6 sub-accounts, we complement the data from the IO table with firm-level data in order to initialize the optimization and construct the linear constraints (see Section 5 below for details).

The key unknowns to be estimated are the inter-sector transaction flows between different firm groups, (i.e., $z_{ij}^{g1,g2}\ \ \forall\ i, j, g1,\ g2$). In addition, we need to estimate sector i's intermediate inputs imported by each firm group g in sector j (i.e., $z_{ij}^{F,g}\ \ \forall\ i, j, g$). We also need to estimate sector-level domestic final demand by firm group g (i.e., $y_j^g\ \ \forall\ j, g$), which can be constructed using firm-level data.

To estimate these values, we develop a quadratic optimization model that uses information from the standard national IO tables, sector-level trade statistics, and firm-level data. The optimization model has the following objective (penalty) function:

$$\min S = \sum_{g1=SL}^{OS}\sum_{g2=SL}^{OS}\left\{\sum_{i=1}^{K}\sum_{j=1}^{K}\frac{\left(\widehat{z_{ij}^{g1,g2}} - z0_{ij}^{g1,g2}\right)^2}{z0_{ij}^{g1,g2}}\right\} + \sum_{g=SL}^{OS}\left\{\sum_{i=1}^{K}\sum_{j=1}^{K}\frac{\left(\widehat{z_{ij}^{F,g}} - z0_{ij}^{F,g}\right)^2}{z0_{ij}^{F,g}}\right\} + \sum_{g=SL}^{OS}\left\{\sum_{j=1}^{K}\frac{\left(\widehat{y_j^g} - y0_j^g\right)^2}{y0_j^g}\right\}, \tag{8}$$

where O stands for ownership and S stands for firm size. Importantly, the solutions to the optimization need to satisfy the following six groups of linear constraints:

$$\sum_{g2=SL}^{OS}\sum_{j=1}^{K}\left(\widehat{z_{ij}^{g1,g2}}\right) + \widehat{y_i^{g1}} = \overline{x_i^{g1}} - \overline{e_i^{g1}} \tag{9}$$

$$\sum_{g1=SL}^{OS}\sum_{i=1}^{K}\left(\widehat{z_{ij}^{g1,g2}}\right) = \overline{x_i^{g2}} - \overline{v_i^{g2}}; \tag{10}$$

$$\sum_{g1=SL}^{OS}\sum_{g2=SL}^{OS}\widehat{z_{ij}^{g1,g2}} = z_{ij}^D; \tag{11}$$

$$\sum_{g=SL}^{OS}\widehat{z_{ij}^{F,g}} = z_{ij}^F; \tag{12}$$

$$\sum_{g=SL}^{OS}\widehat{y_i^g} = y_i^D \tag{13}$$

$$\sum_{g=SL}^{OS}\sum_{j=1}^{K}\widehat{z_{ij}^{F,g}} + y_i^F = m_i, \tag{14}$$

and the non-negativity constraints:

$$\hat{z}_{ij}^{g1,g2} \geq 0;\ \hat{z}_{ij}^{F,g} \geq 0;\ \hat{y}_i^g \geq 0, \tag{15}$$

as well as the adding-up constraints:

$$\sum_{g=SL}^{OS} \overline{v_i^g} = v_i \quad \sum_{g=SL}^{OS} \overline{x_i^g} = x_i \quad \sum_{g=SL}^{OS} \overline{e_i^g} = e_i. \tag{16}$$

In the objective function (8), the target variables we aim to estimate are indicated with ^ while the initial values for the targets are denoted with 0. To kick-start the optimization, we set initial values for all unknown variables using various proportionality assumptions and micro data from Chinese official data sources (see Section 5 for details). Sensitivity analysis, based on different initial values, reveals that our results are not sensitive to using different initial values in the objective function or linear constraints with constants computed from different randomly drawn firm samples (See Section 4 for a discussion about the computation of the standard errors and Section 6.2 for the results).

We use the inverse of the initial values as weights to reduce the "penalty" of large values and thus large deviations on the objective function.[19] Depending on the weights chosen, our optimization model covers a broad range of commonly used linear estimators.[20]

We obtain the linear constraints eqs. (9)-((16)) from two data sources. The first data source is the firm census data, which we use to compute total gross output ($\overline{x_i^g}$), exports ($\overline{e_i^g}$), and value added ($\overline{v_i^g}$) for firm group g in sector i. These variables are indicated with ‾. We will compute standard errors for these constants using bootstrapped firm samples (see Section 4 below). The second data source is the IO table, from which we obtain information on domestic goods from sector i used as intermediate inputs in sector j (z_{ij}^D), imported intermediates from sector i used in sector j (z_{ij}^F), total imports in sector i (m_i), total domestic final demand for sector i goods (y_i^D), and final demand for imported goods i (y_i^F). We keep these values from IO tables constant not only throughout the optimization, but also during bootstrapping.

All constraints need to be satisfied for all i (42 of them) and j (42 of them), g (6 of them), $g1$ (6 of them), and $g2$ (6 of them). These constraints have straightforward economic interpretations. Eq. (9) is a set of supply-and-use balancing (row sum) constraints for the extended IO table. It states that total gross output by firm group in sector i must equal the sum of their use of intermediate inputs, exports, and supply of goods and services to final consumers. Eq. (10) is the set of production and cost balancing constraints. It defines the value of gross output by firm group in sector j as the sum of intermediate inputs and primary factors of production. Eqs. (11) to (14) are a set of adding-up constraints to ensure that the solutions from the model sum up to the aggregate statistics (i.e., domestic final demand, imports, and inter-sector transactions) in the national IO table at both the sector and sector-pair levels. Note that the initial values we set are unlikely to satisfy all of these linear restrictions of the model simultaneously.

Our estimation model is flexible enough to take into account a wide range of information in the optimization process. Additional constraints, such as upper and lower bounds imposed on unknown variables, can be added. Extra terms in the objective function to penalize solutions that deviate substantially from select linear constraints can also be added. Such flexibility is particularly important for obtaining optimal solutions when there are inconsistences in the constants in linear constraints from different data sources.

4. Data Sources and Variable Initialization

As described in Section 3, the initial values and constants in some of the linear constraints of the optimization program are computed using data from China's IO tables and firm-level census. Specifically, we implement the optimization using China's 42-sector "non-competitive" IO tables for both 2007 and 2010, along with the country's firm census for 2008. Both data sources are from China's National Bureau of Statistics (NBS). The firm census data cover over 5 million enterprises in China, including all SOEs and private enterprises from all manufacturing and services sectors. Balance sheet information, such as firms' ownership type, equity share by ownership type, output, value added, four-digit industry code (about 900 categories), exports, employment, original value of fixed assets, and intermediate inputs. We define firms' ownership type based on the firm's registration type or equity share by ownership, similar to Hsieh and Song (2015). Specifically, a firm is considered state (foreign) -owned if it is registered as a state (foreign) company *or* has more than 50% equity owned by state (foreign) investors. The same criterion is used to define private firms. Estimates for both 2007 and 2010 are reported.[21]

For all sector linkages in the IO table, we aim to estimate transactions between any pair of the 6 firm groups: large SOEs (SL), small and medium-sized SOEs (SS), large foreign (FL), small and medium-sized foreign (SF), large private (LP), and small and medium-sized private enterprises (SP). Firm size category (large versus small-and-medium) is determined by firm employment and sales, with sector-specific thresholds specified by the NBS. Table A1 in the appendix reports those criteria.

[19] For example, basic business services tend to have a higher cost share for many sectors

[20] If the weights are all equal to one, the model resembles a constrained least squares estimator. If initial values are used as weights as what we do in this paper, the model resembles a weighted constrained least square estimator. If the weights are set proportional to the variances of the initial values, and if the initial values are statistically independent, the model yields unbiased linear estimates of the true unknown variables (Byron, 1978). If the weights are set exactly equal to the variances of the initial values (Stone, 1984, van der Ploeg, 1988), the model will be identical to the Generalized Least Squares estimator. Finally, as noted by Stone et al. (1942) and proven by Weale (1985), when the errors of the initial values are normally distributed, the solutions satisfy the maximum likelihood criteria.

[21] Notice that changes in the estimates are due to using IO tables from different years, as we only have one year of census data.

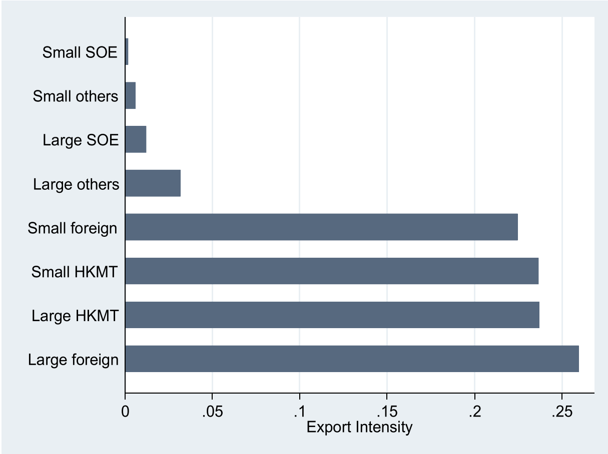

Figure 2. Firm Average Export Intensity.
Source: China's National Bureau of Statistics Firm Census Data (2008)

The decision of putting firms into 6 groups is supported by the underlying firm distributions of export intensity and value added to sales ratios reported in the firm-level data. Figure 2 shows that firm average export intensity differs substantially across ownership types, not so much along the firm size dimension. In particular, foreign firms are a lot more export-oriented than domestic firms. Figure 3 shows that foreign firms also tend to have a higher value added to output ratio than domestic firms. Among domestic firms, large firms tend to have higher value added to output ratios. Among foreign firms, there is little difference in these key variables between Hong Kong SAR, China, Macau, and Taiwan, China (HKMT) firms and non-Chinese foreign firms. Based on these findings, we separate firms based on 3 ownership types and 2 sizes, and group HKMT firms with other foreign firms. Putting firms into more refined categories comes with a cost of having too few firms in each cell and thus less precise estimates.

We then use several aggregate statistics computed from firm census data to divide the aggregate numbers for each sector in the IO table across the 6 different firm groups. Specifically, we distribute each sector's gross output into the various firm groups proportional to their corresponding shares in the sector's total, according to the census data. Similarly, we also assign sectoral exports (but not imports) proportionally to each firm group's share. We also split each sector's labor income and profits (operating surplus) across firm groups based on their corresponding shares in each sector's value-added. We use detailed import data disaggregated by firm ownership type and 8-digit HS category from China's Customs Administration. We first use the United Nations Broad Economic Categories (BEC) code to separate imported intermediates from imported final goods at the HS 6-digit level. We then use customs data to compute the share of each firm group in intermediate imports at the same product level. We use these shares to allocate imports at the sector level according to the IO tables to different firm groups to set the initial values of $z_{ij}^{F,g}$. These firm-group-sector statistics for output, exports, and imports are used in the linear constraints described in (9)-(16).

To initialize all $z0_{ij}$'s in the objective function (8), we need to allocate each industry's total intermediate inputs, both domestic and imported, to different firm groups and sectors. To this end, we first use the NBS firm census to compute output $x0_j^g$ and value added $v0_j^g$ for each firm group in each sector. For each firm-group-sector pair, we compute its share in total intermediate inputs, $x0_j^g - v0_j^g$.

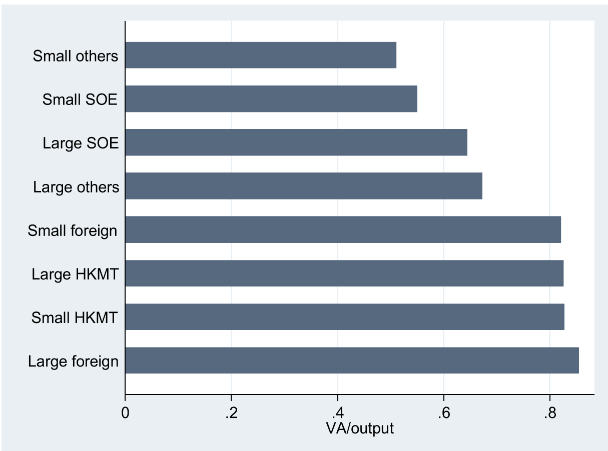

Figure 3. Firm Average Value Added to Output Ratio.
Source: China's National Bureau of Statistics Firm Census Data (2008)

Using these shares, we distribute $z0_{ij}^{D}$ and $z0_{ij}^{F}$ from the national IO table across the 6 firm groups. Tables A4 and A5 in the appendix report the shares of these variables by firm group and sector. The specific procedures to set the initial values for the target variables in the optimization model are described below.

1 It takes two steps to set the initial value for $z0_{ij}^{F,g}$ (imports by group *g* in sector *j* from sector *i*). For sectors that have zero imports of intermediate inputs according to the customs trade statistics, but positive values in the IO table (such as various service sectors), we simply use the shares of each group of firms in the sector's total intermediate inputs as weights to initialize $z0_{ij}^{F,g}$ as

$$z0_{ij}^{F,g} = \frac{\overline{x_j^g} - \overline{v_j^g}}{\sum_{g,j}(\overline{x_j^g} - \overline{v_j^g})} z_{ij}^{F},\ \ (\mathrm{g = SL,\ SS,\ FL,\ FS,\ PL,PS}) \tag{17}$$

where $\overline{x_j^g}$ and $\overline{v_j^g}$ are sector *j*' output and value added by group-*j* firms.

For sectors that have reported imported intermediate inputs, we first compute each firm group's share in the sector's imported inputs based on customs statistics to distribute imported inputs across firm groups. Using this adjusted z_{ij}^{F} and eq. (17), we further allocate the imported inputs by each ownership type to large and small-and-medium firm categories, respectively.

1 To set the initial value for $z0_{ij}^{g1,g2}$ (the volume of domestic intermediates supplied by group g1 in sector i to group g2 in sector j), we first assume that the share of intermediate inputs produced by g1 in sector i equals the share of g1's gross output in sector i. On the user side, we assume that g2's share of intermediate input absorption in sector j equals their share of intermediate inputs in total intermediate inputs demanded by the same sector. All information is available in the firm census data. Based on these two assumptions, we split the original z_{ij}^{D} according to the following formula:

$$z0_{ij}^{g1,g2} = \frac{\overline{x_i^{g1}}}{\overline{x_i}} \frac{(\overline{x_j^{g2}} - \overline{v_j^{g2}})}{(\overline{x_j} - \overline{v_j})} z_{ij}^{D},\ \ (g1,\ \ g2 = SL,\ SS,\ FL,\ FS,\ PL,\ PS), \tag{18}$$

where $\overline{x_i}$ and $\overline{\overline{v_i}}$ are sector *i*' total output and value added, respectively.

Finally, to set the initial value for $y0_i^g$ (total domestic demand for goods and services supplied by firm group *g* in sector *i*), we use the following formula:

$$y0_i^g = \overline{x_i^g} - \frac{\overline{x_i^g}}{\overline{x_i}} \sum_{j=1}^{N} z_{ij}^{D} - \overline{e_i^g}, \tag{19}$$

where z_{ij}^{D} and $\overline{e_i^g}$ are the value of sector's *i* sales to sector *j* and foreign customers, respectively.

5. Computing Standard Errors for the Estimates in the Extended IO Table

Any estimation, by definition, must be associated with measurement errors. One may be particularly concerned about how our estimates are sensitive to the set of initial values and linear constraints we impose in our optimization. In this section, we discuss how to incorporate the conventional bootstrapping procedures in our optimization model to obtain standard errors for the estimates.[22]

Our method relies on the possibility to create many IO tables based on random samples of firms. We randomly draw firm samples with replacement from the 2008 census data set. The number of draws in each firm-group-sector category (out of 6 × 42 categories) is set equal to the actual number of firms in that category according to the census data. Using each random sample, we compute gross output (total sales), exports, wages, and operating surplus for each of the 252 firm-group-sectors.[23] We then use the data from each bootstrapped sample to reset the constants in some of the linear constraints eq. (9)-((10) above) and all the initial values in the objective function (8) in the optimization model in order to estimate a new extended IO table. These bootstrapping and optimization exercises are repeated until we get 2000 simulated IO tables.[24]

[22] Robinson et al. (2001) develop a method to handle measurement errors in cross-entropy minimization by using an error-in-variables formulation. Estimating the error variances in a large data set using their approach is computationally challenging.

[23] Important information to categorize firms is sometimes missing for some firm-sector groups. For those groups, we make the following data assumptions. We assume that all firms in the agricultural sectors are small and medium-sized. Moreover, since the 2008 firm census data do not cover firms from the railroad and transportation sector, we use information from the 135-sector version of IO table to extend the 2007 and 2010 IO tables. In addition, we assume that all firms in the railroad sector are large SOEs, while firms in other transportation sectors are assigned based on their size according to the 2008 firm census data. For service-sector firms with zero export, we use a proportionality assumption to impose the share of exports.

[24] Note that in our bootstrapping exercise, some IO tables generated cannot be used as certain balancing conditions (i.e., eqs. (9)-(16)) are not satisfied. When initializing our quadratic optimization, we need to use aggregated firm level statistics computed from the micro data to set the right hand side values of the balancing conditions eqs. (9)-((10)). Since these statistics are computed from random samples drawn from the firm census, sometimes they can take extreme values. Our quadratic optimization will fail to converge as one of the balancing conditions fails to hold. We discard

With 2000 extended IO tables, we can now construct a distribution of each estimate in the extended IO table. Overall, the magnitudes of the standard errors of the estimates, compared to their estimates using the true sample, are relatively small. Most of them are within the 10% range around the estimate.[25] There are a few exceptions in which the standard errors are large. When reporting our results below, we will provide the 95% confidence intervals of the estimates, whenever applicable. We will also report the standard-error-to-mean ratios of the values used in the linear constraints for different firm groups to show how the large variance of firm values for different firm groups may lower the precision of our estimates.

It is worth noting that developing a method to compute standard errors for the estimates in our IO table and the resulting estimated DVA have a wider appeal. An application is to assess the accuracy of any national IO table. IO tables constructed by statistical agencies are based on firm surveys, and thus contain measurement errors. Some of them are due to reporting errors, while others are due to assumptions made by statisticians in the absence of crucial information.[26] A well-known source of measurement error is the imposition of different proportionality assumptions when information about the distribution of imported inputs across sectors is unknown.[27] Our method of constructing standard errors can be used not only to assess the precision of our estimates, but also to gauge that of the coefficients in any IO tables from statistical agencies, as long as the corresponding micro data for computing standard errors are available.

6. Empirical Findings

Based on the estimates of the model described in Sections 2 and 3, we portray the domestic segment of GVC in China. For clarity, we will report results for 4 firm groups – SOEs, foreign, large private, and small and medium-sized private firms, despite our estimation for 6 firm groups. In other words, we aggregate the two SOEs groups into one, and two foreign groups into one. We could have reported results for all 6 groups or split the IO table based on 4 firm types, but consider our current approach as striking a good balance between clarify of reporting and minimizing aggregation biases.

6.1. Contributions of Different Firm Groups

Let us first report in Table 1 the contributions of different firm groups to the macroeconomic outcomes in China. Besides DVA, all numbers are computed based on the actual data from either 2007 and 2010 IO tables or the 2008 firm census. Columns 1 - 3 in Table 1 show that SOEs accounted for 5% of the total number of firms, 19% of value added, and 9% of employment of China in 2008. These relatively small shares are in part an outcome of years of privatization of SOEs by the Chinese government, especially the small ones in downstream sectors. SOEs' contributions to gross exports and value-added in exports (DVA) in 2007 are 12% and 21%, respectively (columns 4 - 5). The large difference between the two suggests that SOEs have a large share of indirect exports through other firms. Even when SOEs' gross export share declined significantly from 12% in 2008 to 9% in 2010 (columns 6 - 7), their share in DVA actually increased slightly from 21% to 22%. The opposite trends in gross exports versus DVA will be analyzed in greater detail below.

Table 1 also shows that SMEs are numerous and employ the majority of workers in China (column 1). They accounted for 55% and 79% of China's value added and employment in 2008, respectively (columns 2 - 3). In terms of gross exports, their contribution was much smaller – only 28% (column 4). This low share of exports is consistent with the conventional view that most small firms do not export directly because of the potentially high fixed export costs.[28] In terms of DVA, SMEs account for 42% (column 5). The much larger contribution of SMEs to DVA implies that they have a higher share of indirect exports, through other firms. In terms of the aggregate gross exports and DVA, SOEs and SMEs look similar. We will reveal the key underlying differences in terms of their distributions across industries and the channels through which they achieve high DVA ratios below. Unlike SOEs, the shares of SMEs in both gross exports and DVA in exports declined since 2007.

As expected, foreign firms are much more export-oriented. They are small in number, similar to SOEs, but account for close to half of China's gross exports. Their share in total DVA is much smaller though (only 27%). This fact is consistent with the literature that reports a low DVA ratio in Chinese exports, particularly in processing exports (Koopman, Wang, and Wei, 2012; Kee and Tang, 2016). Processing exporters take advantage of the duty-free incentives by importing more intermediates than typical exporters. Given that most of the processing exporters are foreign-owned, the finding of a low DVA ratio of foreign firms' exports is not surprising.

6.2. Domestic Value Added in Exports

We now use our extended IO tables to decompose DVA by firm group into direct and indirect DVA, based on the forward-linkage approach described in Section 2. Results for the backward-linkage approach are reported in Appendix A.

(*footnote continued*)
those tables (less than 10%) and keep drawing until we have a sample of 2000 bootstrapped tables.

[25] Results are available upon request.

[26] See Lenzen et al. (2010) for various reasons for why the numbers reported by a standard IO table may contain measurement errors.

[27] See Puzzello (2012) for an illustration of the potential biases in the measurement of domestic content, foreign content, and factor content in trade, due to the proportionality assumptions made about imported input usage.

[28] See Bernard et al. (2015) for a theoretical model and stylized facts based on US firm-level data.

Table 1
Contribution by Each Firm Group to China's Main Economic Activities.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Number of Firms (2008)	Value Added (2008)	Employment (2008)	Gross Exports (2007)	Estimated DVA (2007)	Gross Exports (2010)	Estimated DVA (2010)
A: Share (%)							
Firm Type							
State-owned	4.73	19.16	9.24	12.07	20.81	9.40	22.02
Foreign	3.01	16.34	6.49	49.47	26.50	56.65	26.67
Large Private	0.22	9.91	4.82	10.08	10.35	10.41	10.10
Small and Medium Private	92.04	54.58	79.45	28.38	42.34	23.54	41.21
B: Value (Billion for values; million for employment)							
Firm Type							
State-owned	188,829	5098	71	1231	1446	1052	1821
Foreign	120,073	4348	50	5046	1841	6340	2205
Large Private	8,836	2637	37	1028	719	1164	835
Small and Medium Private	3,674,676	14520	612	2895	2942	2635	3407
Total	3,992,414	26604	770	10200	6947	11191	8268

Note: Domestic value added in exports (DVA) is estimated using our extended IO tables for 2007 and 2010, respectively. Data on value added and employment are from China's National Bureau of Statistics (NBS) 2008 firm census. Data on gross exports are computed based on IO tables from 2007 and 2010, respectively.

Table 2
Domestic Value Added in Exports (DVA).

A. 2007	(1) Domestic Value Added in Exports (DVA) in Bln RMB	(2) Standard Error/ Mean	(3) DVA/ Gross Exp	(4) Change relative to 2007 (%)
State-owned	1446	0.315	1.17	
	(1169, 1723)			
Foreign	1841	0.071	0.36	
	(1762, 1920)			
Large Private	719	0.217	0.70	
	(590, 848)			
Small and Medium Private	2942	0.236	1.02	
	(2309, 3574)			
Total	6947	0.005	0.68	
	(6787, 7108)			
B. 2010				
State-owned	1821	0.318	1.73	47.4%
	(952, 2690)			
Foreign	2205	0.081	0.35	-4.7%
	(1822, 2589)			
Large Private	835	0.224	0.72	2.5%
	(446, 1224)			
Small and Medium Private	3407	0.235	1.29	27.3%
	(1777, 5037)			
Total	8268	0.004	0.74	8.5%
	(8197, 8339)			

Note: Authors' estimation based on data from the 2008 firm census and the IO tables for 2007 and 2010, respectively. All data used are from China's National Bureau of Statistics. 95% confidence intervals are reported in brackets in column 1. Column 2 reports the ratios of the standard error to mean of the estimates.

Column 1 of Table 2 shows the estimated DVA of different firm groups. The DVA of SOEs is about 1446 billion RMB in 2007, while those of foreign, large, and small and medium-sized private enterprises are respectively 1841, 718, and 2942 billion RMB.[29] The corresponding 95% confidence intervals, reported in parentheses, provide great confidence that our estimated DVA for different firm groups are statistically significant at the conventional levels. Column 2 reports the standard-error-to-mean ratio of each estimate. For 2007, the ratio ranges from only 7% for foreign firms to 32% for SOEs, and similarly for 2010. The relatively lower precision for SOEs' estimated DVA could be due to the larger variance in the underlying values across firms within a sector, which we will verify below.

[29] These numbers in US dollars are about 196, 250, 98, and 399 billion, based on 2007 USD-RMB exchange rate.

Table 3
Indirect DVA (in Billion RMB).

2007	Total Indirect DVA	
State-owned	1150	(666, 1634)
	[80%]	*0.297*
Foreign	853	(648, 1057)
	[46%]	*0.078*
Large Private	520	(321, 718)
	[72%]	*0.192*
Small and Medium Private	1860	(1147, 2572)
	[63%]	*0.206*
Total	4382	(4216, 4548)
	[63%]	*0.019*
2010		
State-owned	1458	(887, 2030)
	[80%]	*0.302*
Foreign	952	(698, 1205)
	[43%]	*0.079*
Large Private	587	(343, 830)
	[70%]	*0.198*
Small and Medium Private	2496	(1611, 3381)
	[73%]	*0.216*
Total	5493	(5317, 5668)
	[66%]	*0.017*

Note: Authors' estimation based on China's firm census data from 2008 and IO tables for 2007 and 2010, respectively. All data are from China's National Bureau of Statistics. The estimated indirect DVA is reported in billion RMB. The share of indirect DVA in total DVA for each firm group is reported in square brackets. The 95% confidence interval of each estimate is reported in parentheses, with the corresponding standard-error-to-mean ratio reported in italics.

Column 3 reports each firm group's ratio of DVA to gross exports (the DVA ratio). Both SOEs and SMEs have the DVA ratio above 1. In 2007, SOEs' DVA ratio is 1.17 while SMEs' ratio is 1.02. As a comparison, the DVA ratios of foreign and large private firms are 0.36 and 0.70, respectively. The finding of a larger-than-unity DVA ratio confirms the results in Table 1 that SOEs' contribution to Chinese exports is much larger if measured in value added terms than in gross terms.[30] In sum, the low DVA ratio of Chinese aggregate exports, as reported in the literature, hides substantial heterogeneity in DVA across firm ownership types and sizes.

Panel B of Table 2 shows the same set of estimates using the 2010 IO table. As reported, all but foreign firms experienced an increase in DVA. The increase was particularly sharp for SOEs and SMEs. SOEs' DVA ratio rose by about 47% to 1.73 while that of SMEs grew by about 27% to 1.29 (column 4). The significant increase in the DVA ratio of SOEs lends some support to the speculation that the state sector has advanced in the Chinese economy in recent years, especially after the global financial crisis in 2008 when the Chinese central government implemented macroeconomic policies to stimulate the economy. The higher-than-unity DVA ratio of SOEs (and also that of SMEs) implies that many non-exporters from the group produce intermediate inputs and services that are embedded in Chinese exports.

Table 3 examines the potential reasons for the pattern of DVA across firm groups, by examining a group's indirect exports (i.e., DVA generated by selling to other firm groups in the domestic production network). The share of indirect exports in a firm group's total DVA is reported in square brackets. The 95% confidence interval of each estimate is reported in parentheses, with the corresponding standard-error-to-mean ratio reported in italics.

First, we find the following pecking order: in 2007, SOEs have the highest share of indirect exports in total DVA (80%), followed by large private firms (72%) and SMEs (63%), with foreign firms having the lowest share (46%). The indirect export share of SOEs remained at 80% in 2010. Put it differently, in both years, 80% of SOEs' DVA was embedded as inputs in other firms' exports. Total indirect DVA of SOEs are estimated to be around 1.15 trillion and 1.46 trillion in 2007 and 2010, respectively. The standard-error-to-mean ratios of these estimates are about 0.3.

SMEs' share of indirect exports in total DVA increased significantly by 10 percentage-points from 63% to 73% between 2007 and

[30] To our understanding, there is no direct evidence to claim that the DVAR is always lower than 1 for both small private firms and SOEs in any country besides ours, as most of the papers in the literature split national IO tables for developing countries (e.g., China and Mexico) and across different firm types (e.g., processing versus non-processing trade as in Koopman, Wang and Wei, 2012). A notable exception is the report by the USITC, 2010, which shows that large firms in the US have their DVAR smaller than 1. But for small private firm this may not true, because most of them also do not export directly. Indirect evidence points to the fact that large firms tend to import, and proportionally more so, compared to small firms (Amiti, Itskhoki, and Konings, 2014; Kee and Tang, 2016; Tintelnot et al., 2018). Thus, larger firms tend to have lower DVAR in exports. To the extent that SOEs in China are large than private firms within an industry, they should import proportionally more than private firms and thus have lower DVAR. As we find the opposite, the distribution of SOEs versus small private firms across industries is probably a more important factor explaining their higher DVAR.

Table 4
Indirect DVA through Different Firm Group (in Billion RMB).

	(1)		(2)		(3)		(4)	
via	State-owned		Foreign		Large Private		Small and Medium Private	
2007								
State-owned	190	(47, 333)	510	(352, 668)	158	(77, 239)	292	(189, 394)
	[13%]	*0.292*	[35%]	*0.362*	[11%]	*0.329*	[20%]	*0.225*
Foreign	121	(53, 189)	430	(346, 514)	105	(60, 151)	197	(174, 219)
	[7%]	*0.088*	[23%]	*0.120*	[6%]	*0.116*	[11%]	*0.030*
Large Private	80	(20, 140)	230	(161, 299)	70	(35, 106)	139	(103, 175)
	[11%]	*0.197*	[32%]	*0.253*	[10%]	*0.229*	[19%]	*0.118*
Small and Medium Private	225	(78, 373)	785	(687, 883)	212	(149, 276)	637	(226, 1048)
	[8%]	*0.163*	[27%]	*0.121*	[7%]	*0.138*	[22%]	*0.318*
Total	616	(494, 734)	1955	(1740, 2171)	546	(445, 647)	1264	(993, 1535)
	[9%]	*0.049*	[28%]	*0.097*	[8%]	*0.081*	[18%]	*0.097*
2010								
State-owned	167	(0, 334)	795	(606, 983)	191	(99, 284)	306	(181, 430)
	[9%]	*0.303*	[44%]	*0.372*	[11%]	*0.340*	[17%]	*0.220*
Foreign	85	(-4, 174)	582	(487, 677)	114	(58, 171)	170	(145, 195)
	[4%]	*0.097*	[26%]	*0.109*	[5%]	*0.125*	[8%]	*0.026*
Large Private	58	(-14, 131)	328	(244, 413)	76	(34, 117)	125	(78, 171)
	[7%]	*0.206*	[39%]	*0.262*	[9%]	*0.238*	[15%]	*0.121*
Small and Medium Private	191	(9, 373)	1321	(1183, 1459)	274	(194, 355)	710	(220, 1200)
	[6%]	*0.177*	[39%]	*0.145*	[8%]	*0.158*	[21%]	*0.304*
Total	501	(357, 646)	3026	(2796, 3256)	655	(544, 767)	1310	(997, 1623)
	[6%]	*0.051*	[37%]	*0.087*	[8%]	*0.079*	[16%]	*0.089*

Note: Authors' estimation based on China's firm census data from 2008 and IO tables for 2007 and 2010, respectively. All data are from China's National Bureau of Statistics. The estimated indirect DVA through each firm group is reported in billion RMB. The share of each firm-group's contribution (column) to each firm group's DVA (row) is reported in square brackets. The shares add up to less than 100%, with the residual being the share of direct DVA in total DVA of the group (row). The 95% confidence interval of each estimate is reported in parentheses, with the corresponding standard-error-to-mean ratio reported in italics.

2010, consistent with the hypothesis that small exporters could be more financially constrained after the global finance crisis to engage in direct exporting. Once again, foreign firms are substantially different from domestic firms and have a much lower share of indirect exports (about 46% in 2007, which decreased to 43% in 2010). Given the prevalence of foreign firms in processing trade and of intra-firm trade associated with vertical FDI, the low indirect export ratio is expected.

In Table 4, we further decompose the estimated indirect DVA into different IO channels. Specifically, we report a group's indirect DVA through the four firm groups. First and foremost, most of SOEs' indirect exports went through private enterprises. In particular, 84% (67%/80%) and 89% (71%/80%) of SOEs' indirect DVA exports in 2007 and 2010, respectively, were through private firms. Foreign firms accounted for over 40% (35%/80%) and 55% (44%/80%) of SOEs' indirect exports in 2007 and 2010, respectively (column 2). On the other hand, SMEs accounted for about a quarter (20%/80%) of their indirect exports in 2007, and declined in importance to about 20% (17%/80%) in 2010 (column 4). Based on 2000 random samples bootstrapped from firm census, the standard errors of these estimated channels of indirect exports are largely robust.

The shares of indirect exports for both large private firms and SMEs are also high, though significantly lower than that of SOEs. Foreign firms play an important role in helping large firms to export indirectly than SMEs, due to their high export orientation. The role of SMEs in helping other firms to export declined between 2007 and 2010.

Before explaining the different patterns of DVA across ownership types, let us discuss the large standard errors of some of the estimates, especially for SOEs. Notice that the precision of the estimates for each firm group is naturally affected by the underlying standard errors of the related firm-level values. When there are only a few firms operating in a sector with a large difference in major variables, bootstrapping observations with replacement implies a high likelihood that the same firm is drawn multiple times, yielding aggregates that could differ widely across bootstrapped samples for that firm group. In other words, the resulting bootstrapped standard error of an aggregate value will be large when the sample size is small.

To empirically verify this hypothesis, we report in Table 5 the standard-error-to-mean ratios of the key values, $x0_i^g$, $e0_i^g$, and $v0_i^g$, which were used to initialize the constants in the objective function and some of the linear constraints, based on different bootstrapped samples drawn from the 2008 firm census. As fully described in eq. (17)-(19), the values we use to initialize the model are computed indirectly using these three key values. They are also used to construct weights to distribute the IO table's statistics to the firm-group-sector level, which will then be used as linear constraints (9) and (10). Thus, the distributions of $x0_i^g$, $e0_i^g$, and $v0_i^g$ are the major drivers of the differences across the estimates of the extended IO tables constructed with bootstrapped samples. Constants in

Table 5
Standard-Error-to-Mean Ratios of the Key Values from Bootstrapped Samples.

2007	State-owned	Foreign	Large Private	Small and Medium Private
gross output (x_i^g)	0.019	0.013	0.029	0.005
exports (e_i^g)	0.028	0.021	0.162	0.006
value added (v_i^g)	0.116	0.042	0.117	0.037
2010				
gross output (x_i^g)	0.018	0.013	0.027	0.005
exports (e_i^g)	0.027	0.020	0.142	0.005
value added (v_i^g)	0.114	0.035	0.108	0.032

Note: Authors' estimation and calculation based on China's National Bureau of Statistics firm census data from 2008. Notice that only the statistics for the initial values *directly* computed from the firm data are reported. Initial values that are computed indirectly using such firm-based initial values, including imported intermediate inputs by firm type g ($z0_{ij}^{Fg}$), domestic inter-sector transactions between two firm types ($z0_{ij}^{g1g2}$), and domestic demand for firm type g's output in sector i ($y0_i^g$). See eq. (17)-(19) in the main text about how the initial values in the objective function are computed based on x_i^g, e_i^g and v_i^g.

those adding-up constraints that are not differentiated across firm groups are obtained directly from the IO table at the sector level, and remain constant across bootstrapped samples.[31]

As reported in Table 5, the bootstrapped standard-error-to-mean ratios of the constants in the linear constraints for most firm groups are smaller than 0.05, with those for SOEs' value added (0.116) and large private firms' exports (0.162) and value added (0.117) being the exceptions. These findings are consistent with the high standard-error-to-mean ratios for the estimated direct and indirect DVA for state-owned and large private firms reported in Table 3. These are the firm groups that have a small number of firms.[32]

6.3. The Prevalence of State-owned Enterprises both within and between Industries

We now aim to provide reasons for the similarity in the DVA ratio between SOEs and SMEs by examining the cross-industry pattern of indirect exports across firm groups. Table 6 shows a substantial heterogeneity in indirect export shares (in total DVA) across 14 broad sectors. “Upstream” sectors, such as energy and mining; metal and non-metallic mineral extraction; electricity, gas and water supply; as well as the financial sector all have very high indirect export shares (over 90%). One reason is that these sectors tend to be non-tradable, either by nature or due to protection by the governments. Most of their outputs are used as essential intermediate inputs and services by other firms domestically, including director exporters.[33] Hence, focusing only on firms' gross exports in analyzing their export participation can substantially underestimate their actual participation in GVC.

In addition to the cross-industry variation, within a sector we also see a non-negligible variation in the indirect export share across firm groups. For instance, in the “Light manufacturing” sector, the ratio of indirect to direct DVA in exports was 50% in 2007, one of the lowest, but the ratio for SOEs was 75%. That ratio for SOEs further increased to 92% in 2010. In wholesale and retail trade, while the indirect-to-direct export ratio was 24% (38%) for SMEs in 2007 (2010), it was 83% (61%) for foreign firms. These differences may reflect the predominance of small and medium-sized private trade intermediaries, while foreign firms are less likely to be engaged in services (possibly due to policy restrictions), they are more likely to export goods either by themselves or through other domestic trade intermediaries. A casual observation shows that SOEs tend to have a higher indirect export share in sectors that are associated with a lower average indirect export share, such as electronic equipment; while SMEs tend to have a higher indirect export share in industries that have a higher average indirect export share, such as energy and mining, and the financial sector.

To analyze these channels more systemically and show that the relative upstream positions held by SOEs is not only a between-sector phenomenon but also a within-sector one, we use the method proposed by Antràs et al. (2012) to compute the upstreamness indices by firm group in each sector. Briefly speaking, the upstreamness index captures the average distance between a sector and final-good consumers. Appendix B describes several important extensions we make to Antràs et al. (2012), and how we use the extended IO table to compute such indices. Table A7 in the appendix reports the 240 upstreamness indices (40 industries x 4 firm groups), along with the industry's upstreamness index computed based on the standard IO table. Table 7 reports that the top 5 most “upstream” industries (out of 40) in China were “Extraction of Petroleum and Natural Gas”, “Mining of Ferrous Metal Ores”, “Mining and Washing of Coal”, “Production and supply of Electricity and heat”, “Processing of Petroleum, Coking and Nuclear Fuel” in 2007. The values of upstreamness for these sectors range between 4 and 5, meaning that these sectors are on average 4-5 sectors away before reaching final-good consumers. The bottom 5 “upstream” sectors were “Real Estate”, “Health and Social service”, “Education”,

[31] These include imports in sector i (m_i in eq. (14)), domestic intermediate inputs sold among industries (z_{ij}^D in eq. (11)), imported intermediate inputs sold among industries (z_{ij}^F in eq. (12)), and the demand for final goods in sector i that are either domestic or imported (y_i^D in eq. (13) and y_i^F in eq. (14)).

[32] However, it is difficult to reconcile the small standard-error ratios for small and medium-sized firms' initial values on the one hand, and larger ratios for their estimated DVA as reported in Table 3, on the other. One possibility is that small and medium-sized firms participate in GVC by selling primarily to state-owned and large private firms in the domestic economy. The less precise estimates of the latter two groups' DVA may in turn lower the precision of small and medium-sized firms' estimated DVA. Again, IO linkages matter.

[33] In the case of banking, only 5 major state-owned banks have dominated different segments of the sector due to entry restriction to private firms.

Table 6
Indirect DVA/ Total DVA (4 groups, 14 sectors) (%).

Panel A: 2007			Sector		
	All	SOE	FE	LP	SME
Energy and mining	94.03	94.57	92.30	93.01	94.58
Metal and non-metallic mineral extraction	90.14	89.15	88.18	92.17	91.17
Light manufacturng	49.61	74.83	36.87	58.18	51.70
Petrochemical	74.89	87.58	62.67	75.69	79.79
Metal and non-metal processing	67.29	68.87	69.00	75.37	60.58
Machinery and equipment	47.02	72.52	36.86	53.35	46.90
Electronic equipment	20.75	45.45	16.71	34.41	36.29
Other manufacturing	76.35	59.75	29.67	36.68	87.02
Electricity, gas and water supply	99.41	99.51	99.56	98.85	98.95
Building industry	33.63	33.18	35.94	33.39	33.38
Transportation and warehousing	52.87	59.78	87.92	90.06	40.50
Wholesale and retail trade	42.72	72.22	82.72	76.36	24.26
Financial sector	98.18	97.94	97.82	97.78	98.51
Other Services	66.02	75.35	79.31	80.82	45.23
Total	63.07	79.54	46.31	72.24	63.23
Panel B: 2010					
Sector	All	SOE	FIE	LP	SME
Energy and mining	96.55	95.95	93.34	96.64	99.23
Metal and non-metallic mineral extraction	94.77	97.65	81.86	99.53	94.27
Light manufacturng	53.61	91.84	32.43	61.02	68.09
Petrochemical	74.41	79.82	55.62	78.30	87.82
Metal and non-metal processing	73.16	76.08	56.37	79.06	82.83
Machinery and equipment	48.18	72.16	34.08	48.43	65.87
Electronic equipment	31.85	71.90	24.54	46.09	71.75
Other manufacturing	55.35	92.84	44.74	67.41	65.20
Electricity, gas and water supply	99.23	99.09	99.88	99.23	99.69
Building industry	17.82	28.08	76.61	26.66	9.65
Transportation and warehousing	69.10	71.17	74.42	90.52	66.08
Wholesale and retail trade	45.51	53.18	60.98	55.78	38.05
Financial sector	96.75	97.26	97.43	97.90	96.43
Other Services	70.49	71.60	77.65	86.97	61.10
Total	66.43	80.10	43.15	70.30	73.25

Note: SOE = state-owned enterprises; FE = foreign enterprises. LGE = large private enterprises; SME = small and medium-sized private enterprises. Authors' estimation and calculation based on data from the 2008 firm census. All data are from China's National Bureau of Statistics. Italic fonts indicate industries that have indirect export share exceeding 90%. Boldface denotes the highest among the four ownership types within the industry.

"Construction industry", "Public administration and social organization" in the same year.

Consistent with the high indirect export ratios, SOEs tend to have the highest upstreamness index among all firms types within each sector, while SMEs tend to have the lowest upstreamness index, particularly for the least upstream sectors. Figure 4 plots the state-owned, foreign, large private, and SMEs' upstreamness indices against the industry overall upstreamness indices, which are estimated using the original IO table. The upstreamness indices for SOEs (blue squares) are mostly above the 45-degree line, suggesting that SOEs often command a more upstream position than other firm groups along a value chain, even in the same sector. SMEs, on the other hand, are often much closer to final-good consumers.

7. Concluding Remarks

This paper proposes a method to extend a standard input-output (IO) table to incorporate firm heterogeneity when portraying the domestic segment of global value chains in a country. Using conventional IO tables, firm-level data for both manufacturing and service sectors, and quadratic optimization techniques, we estimate direct and indirect DVA for different firm groups in China. We decompose a firm group's indirect DVA into different domestic IO channels through which DVA was generated. Our approach is flexible enough to incorporate the standard bootstrapping techniques to compute standard errors and confidence intervals for the estimate values of the extended IO table, as well as the corresponding estimated DVA.

We find that in China, both SOEs and SMEs have much higher shares of indirect exports and DVA ratios, compared to foreign and large domestic private firms. Using China's IO tables for 2007 and 2010 respectively, we find evidence of increasing DVA ratios for all firm groups, particularly for SOEs. These findings suggest that China's SOEs still play an important role in shaping its domestic segment of GVCs, despite their diminishing importance in other macroeconomic outcomes.

Our findings shed light on the consequences of a unique sequence of privatization in China. Years of privatization have led to the dominance of large SOEs in upstream sectors. Based on DVA, we find that Chinese firms' engagement in GVC could be a reason for the observed return to state capitalism in the country. We leave the econometric analysis about the political-economic factors behind the unique sequence of privatization and the resulting economic effects for future research.

Table 7
Top and Bottom Industry Upstreamness.

Code	Sector	All	By Type			
			SOE	FE	LGE	SME
2007						
Top 5						
3	Extraction of Petroleum and Natural Gas	5.09	6.02	5.31	4.99	4.39
4	Mining of Ferrous Metal Ores	5.03	5.80	5.79	5.27	4.30
2	Mining and Washing of Coal	4.90	5.72	5.35	4.91	3.98
23	Production and supply of Electricity and heat	4.46	5.09	4.69	4.35	3.75
11	Processing of Petroleum, Coking and Nuclear Fuel	4.27	5.22	4.77	4.04	3.59
Bottom 5						
33	Real Estate	1.67	2.65	2.58	1.53	1.22
40	Health and Social service	1.26	1.50	1.48	1.48	1.08
39	Education	1.20	1.43	1.46	1.31	1.05
26	Construction industry	1.06	1.08	1.24	1.08	1.02
42	Public administration and social organization	1.02	1.05	1.10	1.05	1.01
2010						
Top 5						
3	Extraction of Petroleum and Natural Gas	5.22	6.31	4.91	5.32	4.22
2	Mining and Washing of Coal	5.04	5.66	5.84	5.24	4.68
4	Mining of Ferrous Metal Ores	5.13	5.86	5.09	5.04	4.68
23	production and supply of Electricity and heat	4.60	5.31	4.30	4.14	3.85
11	Processing of Petroleum, Coking and Nuclear Fuel	4.38	5.57	5.08	4.19	4.06
Bottom 5						
33	Real Estate	1.60	3.41	3.00	1.46	1.22
40	Health and Social service	1.20	1.34	3.03	1.37	1.05
39	Education	1.09	1.39	1.77	1.11	1.02
26	Construction industry	1.06	1.10	2.83	1.09	1.02
42	Public administration and social organization	1.03	1.11	2.50	1.13	1.01

Note: Authors' estimation based on data from 2007 IO tables. SOE = state-owned enterprises; FE = foreign enterprises. LGE = large private enterprises; SME = small and medium-sized private enterprises. Bolded face denotes the highest in each row for the top 5, and the lowest in each row for the bottom 5. there are altogether 40 sectors.

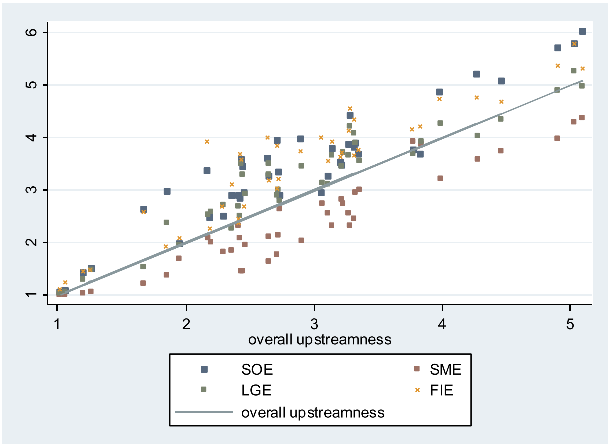

Figure 4. Upstreamness of by Ownership Type. Source: Chinese National Bureau of Statistics (2007) IO table and industrial firm census data. SOE = state-owned enterprises; SME = small and medium-sized enterprises; LGE = large private enterprises; FIE = foreign invested enterprises.

Appendix A. : The Backward-Linkage Approach

To implement the backward-linkage approach that decomposes each firm group's gross exports into their original value-added source by sector and firm-type, we pre-multiply both sides of eq. (5) by the 1×252 unit row vector u. This operation essentially sums up each sector-firm-type's DVA vertically to obtain a measure of DVA at the sector-firm-type level. Formally, the backward-linkage based DVA in exports is

Table A1
Classification of Large, Medium and small firms (NBS of China, 2011).

Industry	Indicator	Unit	Large	Medium	Small
Manufacture	Employment	Persons	> = 1000	300-1000	< 300
	Total Sales	RMB10,000	> = 40000	2000-40000	< 2000
	Total Assets	RMB10,000	> = 40000	4000-40000	< 4000
Construction	Total Sales	RMB10,000	> = 80000	6000-80000	< 6000
	Total Assets	RMB10,000	> = 80000	5000-80000	< 5000
Wholesales	Employment	Persons	> = 200	20-200	< 20
	Total Sales	RMB10,000	> = 40000	5000-40000	< 5000
Retails	Employment	Persons	> = 300	50-300	< 50
	Total Sales	RMB10,000	> = 20000	500-20000	< 500
Transportation	Employment	Persons	> = 1000	300-1000	< 300
	Total Sales	RMB10,000	> = 30000	3000-30000	< 3000
Postal Services	Employment	Persons	> = 1000	300-1000	< 300
	Total Sales	RMB10,000	> = 30000	2000-30000	< 2000
Accommodation & Catering	Employment	Persons	> = 300	100-300	< 100
	Total Sales	RMB10,000	> = 10000	2000-10000	< 2000
Finance and Banking	Employment	Persons	> = 200	< 200	
	Total Sales	RMB10,000	> = 30000	< 30000	
Real Estates	Employment	Persons	> = 200	< 200	
	Total Sales	RMB10,000	> = 30000	< 30000	
Other Service Industries	Employment	Persons	> = 500	< 500	

1. Manufacture above includes three industries: mining, manufacturing and Electricity, Gas, and Utility production and supply.
2. Total sale in manufacturing industry is expressed by the annual sale/revenue of products calculated according to the current statistic system; total sale in construction firms is represented by the annual receipt from projects done according to the current statistic system; total sale of wholesales and retails is shown as the annual sales calculated according to the current accounting forms; total sale in transportation, postal services, accommodation and catering firms is the annual operating revenue calculated according to the current statistic system; the total asset is replaced by accumulated assets according to the current statistic system.
3. The large and medium firms should meet all the criteria defined for the large firm and medium firm, respectively. Otherwise, it will be classified to the next lower category of firm size.
Other definitions (authors' definition according to the rule of NBS of China):
Large firms of finance and banking industry are those firms with more than 200 employees and more than 300 million Yuan (RMB) in sales.
Large firms of real estate industry are those firms with more than 200 employees and more than 300 million Yuan (RMB) in sales.
Large firms of other service industries are those firms with more than 500 employees.
Remarks: the lowest standard of employment and the highest standard of total sale are used to define large firms considering the properties of finance and banking industry and real estate industry. The firm in other service industries will use the only criteria of employment to distinguish large firms and small and medium-sized firms.

$$\mathbf{DVA_{bw}} = \mathbf{uDVA} = \mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}} + \mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B}-\mathbf{I})\hat{\mathbf{E}}. \tag{A-1}$$

By replacing $\mathbf{u}\hat{\mathbf{A}}_V\mathbf{B}\hat{\mathbf{E}}$ in eq. (A-1) by eq. (4), we can completely decompose China's gross exports according to its various DVA sources as follows:

$$\mathbf{u}\hat{\mathbf{E}} = \mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}} + \mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B}-\mathbf{I})\hat{\mathbf{E}} + \vartheta\mathbf{A}^{\mathbf{m}}\mathbf{B}\hat{\mathbf{E}}. \tag{A-2}$$

Notice that all terms in eq. (A-2) are 1×252 row vectors.

The first column of the first term, $\mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}}$, represents the direct DVA by large state-owned enterprises (SL) in all 42 sectors. Notice the direct DVA based on the forward-linkage and backward-linkage approaches are identical (i.e. $(\mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}})^{\mathbf{T}}$ in eq. (A-2) = $\hat{\mathbf{A}}_{\mathbf{V}}\hat{\mathbf{E}}\mu$ in eq. (6)). However, the indirect value-added exports measures can be very different for each firm group-sector pair. The two measures are only equal to each other at the country level (see Wang et al., 2013 for details). In the second term, $\mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B}-\mathbf{I})\hat{\mathbf{E}}$, the first column is the sum of 6 multiples as

$$\tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{SL}}(\mathbf{B}^{\mathbf{SL,SL}}-\mathbf{I})\hat{\mathbf{E}}^{\mathbf{SL}} + \tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{SS}}\mathbf{B}^{\mathbf{SS,SL}}\hat{\mathbf{E}}^{\mathbf{SL}} + \tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{FL}}\mathbf{B}^{\mathbf{FL,SL}}\hat{\mathbf{E}}^{\mathbf{SL}} + \tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{FS}}\mathbf{B}^{\mathbf{FS,SL}}\hat{\mathbf{E}}^{\mathbf{SL}} + \tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{SL}}\mathbf{B}^{\mathbf{PL,SL}}\hat{\mathbf{E}}^{\mathbf{SL}} + \tilde{\mathbf{u}}\mathbf{B}^{\mathbf{PS,SL}}\hat{\mathbf{E}}^{\mathbf{SL}} \tag{A-3}$$

where $\tilde{\mathbf{u}}$ is a 1×42 row vector. $\tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{SL}}(\mathbf{B}^{\mathbf{SL,SL}}-\mathbf{I})\hat{\mathbf{E}}^{\mathbf{SL}}$ is large state-owned enterprises' indirect DVA via other large state-owned enterprises; $\tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{SS}}\mathbf{B}^{\mathbf{SS,SL}}\hat{\mathbf{E}}^{\mathbf{SL}}$, $\tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{FL}}\mathbf{B}^{\mathbf{FL,SL}}\hat{\mathbf{E}}^{\mathbf{SL}}$, $\tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{FS}}\mathbf{B}^{\mathbf{FS,SL}}\hat{\mathbf{E}}^{\mathbf{SL}}$, $\tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{SL}}\mathbf{B}^{\mathbf{PL,SL}}\hat{\mathbf{E}}^{\mathbf{SL}}$, and $\tilde{\mathbf{u}}\hat{\mathbf{A}}_{\mathbf{V}}^{\mathbf{SL}}\mathbf{B}^{\mathbf{PS,SL}}\hat{\mathbf{E}}^{\mathbf{SL}}$ represent small state-owned, large foreign, small foreign, large private, and small and medium-sized enterprises' value-added embodied in large state-owned enterprises' gross exports, respectively. Other columns of $\mathbf{u}\hat{\mathbf{A}}_{\mathbf{V}}(\mathbf{B}-\mathbf{I})\hat{\mathbf{E}}$ in eq. (A-2) can be interpreted similarly for other firm groups. In sum, eq. (A-3) provides detailed information about the sources of DVA produced by each firm group. By considering all 42 sectors within each firm-group-pair, we can analyze the value-added composition for each firm group by sector.[34]

[34] The full decomposition of each firm group's exports by value-added sourced from the 6 firm groups and 42 sectors are available upon request.

Table A2
Indirect DVA/ Total DVA 2007 (6 types, 42 sectors).

Sector	SL	SS	FL	FS	PL	PS
Mining and Washing of Coal	0.96	0.93	0.92	0.90	0.93	0.95
Extraction of Petroleum and Natural Gas	0.92	0.84	1.00	0.85	0.88	0.99
Mining of Ferrous Metal Ores	1.00	0.95	0.90	1.00	1.00	0.95
Mining of Non-Ferrous Metal Ores	0.75	0.74	0.82	0.72	0.82	0.65
Foods and Tobacco	0.66	0.65	0.65	0.67	0.66	0.80
Manufacture of Textile Products	0.62	0.59	0.50	0.30	0.44	0.60
Wearing apparel, leather, fur, down and related products	0.67	0.66	0.40	0.13	0.48	0.23
Processing of wood and Manufacture of Furniture	-	0.69	0.57	0.40	0.58	0.40
Paper Products and Articles for Culture, Education and Sports Activities	0.87	0.84	0.74	0.46	0.81	0.55
Processing of Petroleum, Coking and Nuclear Fuel	0.88	0.91	0.84	0.85	0.90	0.89
Manufacture of Chemical Products	0.82	0.87	0.72	0.49	0.67	0.78
Manufacture of non-ferrous metal products	0.62	0.60	0.46	0.27	0.40	0.42
Smelting and Rolling of metals	0.66	0.89	0.86	0.81	0.76	0.88
Manufacture of Metal Products	0.80	0.79	0.70	0.41	0.74	0.36
Manufacture of General Purpose and Special Purpose Machinery	0.76	0.82	0.67	0.33	0.66	0.52
Manufacture of Transport Equipment	0.63	0.70	0.51	0.59	0.55	0.65
Manufacture of Electrical Machinery and Equipment	0.76	0.75	0.30	0.24	0.44	0.37
Manufacture of Communication Equipment, computers and Other Electronic Equipment	0.62	0.70	0.17	0.27	0.45	0.61
Manufacture of Measuring Instruments and Machinery for Office Work	0.18	0.20	0.06	0.09	0.14	0.10
Handicrafts and other Manufacturing	1.00	0.58	0.36	0.26	0.39	0.25
Scrap and Waste						0.98
production and supply of Electricity and heat	1.00	0.99	0.99	0.99	0.99	0.99
Production and Supply of Gas	1.00	1.00	1.00	1.00	1.00	1.00
Production and Supply of Water	1.00	1.00	1.00	1.00	1.00	1.00
construction industry	0.38	0.38	0.31	0.38	0.38	0.38
Transportation and warehousing	0.82	0.54	0.89	0.90	0.91	0.45
Post service	0.75	0.75	0.76	0.78	0.80	0.77
IT industry	0.76	0.76	0.76	0.76	0.76	0.76
wholesale and retailing	0.72	0.74	0.82	0.82	0.76	0.28
Hotels and Catering Services	0.74	0.75	0.75	0.75	0.75	0.75
Finance	0.98	0.98	0.88	0.98	0.98	0.99
Real Estate	1.00	1.00	1.00	1.00	1.00	1.00
Leasing and commerce service	0.56	0.44	0.60	0.57	0.60	0.18
Research and test development industry	0.91	0.91	0.91	0.90	0.91	0.91
Polytechnic Services	1.00	1.00	1.00	1.00	1.00	1.00
Water, environment and public facilities	1.00	1.00	1.00	1.00	1.00	1.00
Resident and Other Services	0.81	0.81	0.80	0.81	0.81	0.82
Education	0.86	0.87	0.86	0.87	0.87	0.87
Health and Social service	0.88	0.88	0.88	0.88	0.88	0.88
Culture , Sports and entertainment	0.57	0.57	0.57	0.57	0.57	0.57

Note: SL, SS, FL, FS, PL, and PS stand for large state-owned, small state-owned, large foreign, small foreign, large private, and small private firms, respectively.

Results on DVA based on the Backward-Linkage Approach

So far, we have been using the forward-linkage approach to estimate direct and indirect DVA by firm group, which involves summing up the entries of $\hat{\mathbf{A}}_{\mathbf{V}}\mathbf{B}\hat{\mathbf{E}}$ (in eq. (5)) horizontally along each row of the matrix. In this section, we show how to use the backward-linkage approach and answer the question: "*For each dollar of Chinese exports (aggregate or by firm group), how much of it is ultimately coming from state-owned, foreign, large private and small and medium-sized firms, respectively?*" While the forward-linkage approach focuses on the channels through which each firm group's DVA (by sector or at the aggregate) is generated, the backward-linkage approach decomposes a country's gross exports into its direct VA and indirect VA from different firm groups. The decomposition can be done for each firm group as well. For example, state-owned enterprises' gross exports can be decomposed into its own direct DVA, but also domestic VA originating from all other upstream firm groups, including other state-owned enterprises, as well as other firm groups' VA embedded in inputs used to produce those exports.[35] This decomposition exercise permits an analysis of the distribution of DVA across firm groups embedded in each group's downstream exports, complementing the forward-linkage approach that focuses on the "paths" of DVA.

Using this backward-linkage DVA measure, we provide another set of results to examine how the domestic VA in Chinese exports is distributed across firm groups, and how the distribution changed between 2007 and 2010. As reported in column (1) of Table A6, of the 10 trillion RMB Chinese gross exports in 2007, 14% can be attributed to state-owned enterprises, directly and indirectly; while the contribution by FIE, LP, and SME are 18%, 7% and 29%, respectively. The findings of high contributions by state-owned and small

[35] Such a backward-linkage perspective aligns well with case studies of GVC of specific sectors and products, such as the iPod or iPhone examples frequently cited in the literature.

Table A3
Original data from NBS Firm Census (2008) and customs (2007) used to extend the IO table.

	Unit: %	Output						Value Added						Exports					
		SL	SS	FL	FS	PL	PS	SL	SS	FL	FS	PL	PS	SL	SS	FL	FS	PL	PS
2	Mining and Washing of Coal	47	5	2	0	9	36	52	5	2	0	10	30	67	0	3	0	21	8
3	Extraction of Petroleum and Natural Gas	53	12	0	2	30	2	53	11	0	1	33	1	15	63	0	11	12	0
4	Mining of Ferrous Metal Ores	10	6	2	3	7	72	13	8	3	3	9	64	0	0	24	0	0	76
5	Mining of Non-Ferrous Metal Ores	3	7	1	6	4	78	5	9	1	6	6	73	5	8	1	30	1	56
6	Foods and Tobacco	11	3	9	18	11	48	27	3	9	15	11	35	2	1	8	43	11	34
7	Manufacture of Textile Products	1	1	4	19	18	57	1	1	4	19	17	57	1	1	10	38	15	35
8	Wearing apparel, leather, fur, down and related products	0	1	10	35	11	43	0	1	11	36	10	41	0	0	14	51	8	27
9	Processing of wood and Manufacture of Furniture	0	1	5	20	6	68	0	1	5	20	7	67	0	1	13	45	8	33
10	Paper Products and Articles for Culture, Education and Sports Activities	3	3	11	26	8	50	3	3	10	28	8	48	0	1	24	53	3	19
11	Processing of Petroleum, Coking and Nuclear Fuel	34	4	5	4	34	19	28	5	5	6	32	24	63	0	7	8	19	2
12	Manufacture of Chemical Products	7	3	8	22	14	46	7	3	9	22	15	44	6	1	14	45	13	21
13	Manufacture of non-ferrous metal products	1	4	3	14	9	69	1	4	4	14	9	67	1	1	9	43	12	34
14	Smelting and Rolling of metals	25	2	7	7	29	30	31	2	8	6	29	24	40	1	9	16	26	8
15	Manufacture of Metal Products	2	3	6	25	7	58	2	3	6	24	8	57	2	2	22	41	8	26
16	Manufacture of General Purpose and Special Purpose Machinery	7	4	7	19	11	52	8	4	8	20	11	48	5	1	16	40	14	23
17	Manufacture of Transport Equipment	16	3	25	14	18	24	15	3	29	14	17	21	13	2	29	20	25	11
18	Manufacture of Electrical Machinery and Equipment	2	2	15	21	18	42	2	2	16	21	18	41	1	1	34	36	14	15
19	Manufacture of Communication Equipment, computers and Other Electronic Equipment	2	1	63	19	8	8	3	1	51	22	11	12	1	0	76	16	6	2
20	Manufacture of Measuring Instruments and Machinery for Office Work	3	4	30	27	7	30	3	5	17	31	7	36	0	0	56	32	4	7
21	Handicrafts and other Manufacturing	0	2	8	30	6	55	0	1	9	31	6	52	0	0	12	43	6	39
22	Scrap and Waste	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100
23	production and supply of Electricity and heat	54	25	2	5	3	10	49	29	2	6	4	10	14	82	0	0	1	2
24	Production and Supply of Gas	10	15	7	30	5	32	11	14	10	31	4	30	29	9	0	62	0	0
25	Production and Supply of Water	17	45	1	13	1	23	13	45	1	20	0	21	15	1	0	81	0	3
26	construction industry	18	13	0	1	15	53	6	10	0	1	6	77						
27	Transportation and warehousing	14	30	6	0	2	47	18	24	5	0	0	52						
28	Post service	48	39	6	1	0	5	40	43	6	2	0	9						
29	IT industry	5	18	18	21	10	27	7	21	21	23	8	20						
30	wholesale and retailing	13	12	4	3	10	58	14	10	5	3	9	59						
31	Hotels and Catering Services	3	12	9	5	6	66	5	21	9	8	6	50						
32	Finance	13	17	0	3	1	66	7	26	0	4	1	63						
33	Real Estate	5	5	9	5	32	44	5	7	11	5	32	40						
34	Leasing and commerce service	10	21	6	9	6	49	16	21	2	7	5	51						
35	Research and test development industry	22	28	5	7	11	27	29	15	9	8	8	32						
36	Polytechnic Services	27	13	3	4	16	36	26	14	3	4	13	40						
37	Water, environment and public facilities	10	26	2	5	7	51	10	23	3	5	10	50						
38	Resident and Other Services	3	6	2	4	8	77	2	5	1	3	8	80						
39	Education	1	6	1	2	18	72	2	6	1	2	19	71						
40	Health and Social service	15	11	1	1	11	61	12	12	1	1	10	64						
41	Culture , Sports and entertainment	29	34	2	3	4	29	24	31	3	3	4	34						
42	Public administration and social organization	0	12	0	0	2	86	0	11	0	0	2	87						
Total	14	8	9	10	14	46	15	9	9	11	13	44	5	1	39	30	11	15	

Note: SL, SS, FL, FS, PL, and PS stand for large state-owned, small state-owned, large foreign, small foreign, large private, and small private firms, respectively.
Data Sources: (1) 2008 China's NBS Firm Census. Data for Sector 27 (Transportation and warehousing) is inferred from information from 2008 NBS Economic Census and the railway sector in the 2007 135-sector I/O table. (2) Import data are from 2007 customs. (3) Total is the sum of all data for manufacturing, mining and services (agriculture is excluded).

and medium-sized enterprises to China's exports resonate well with the findings that both types of firms have high DVA ratios, as reported in Table 2 of the main text.

We also decompose each firm group's gross exports into contributions from different firm groups' indirect exports. For instance, as shown in column (2), we find that for each dollar of enterprises' gross exports, state-owned enterprises themselves contribute about 39 cents (24 cents directly and 15 cents indirectly), followed by 18 cents from SME and 10 cents from FIE. Imports account for 26 cents, lower than their contribution to China's aggregate gross exports. Notice that the numbers along the diagonal of Table A5 are always the highest compared to other numbers in the same column, suggesting that each firm group contributes the most VA to its own gross exports, compared to other firm groups.

The lower panel of Table A6 reveals that while Chinese gross exports increased by only 9.7% from 2007 to 2010, the contribution by state-owned enterprises in terms of DVA increased by 14.8%. Specifically, for each dollar of Chinese gross exports, 16 cents came from state-owned enterprises in 2010, compared to 14 cents in 2007. State-owned enterprises are not the only group that experienced an increase in DVA shares between the two years. All three other groups also experienced an increase, at the expense of foreign VA (imports). These results

Table A4
Original data from NBS Firm Census (2008) and customs (2007) used to extend the IO table (cont).

	Unit: %	Employment						Imported Materials		
		SL	SS	FL	FS	PL	PS	SOE	FE	Others
2	Mining and Washing of Coal	53	8	1	0	7	32	33	5	61
3	Extraction of Petroleum and Natural Gas	66	2	0	0	29	3	37	0	63
4	Mining of Ferrous Metal Ores	13	6	1	2	7	70	65	2	32
5	Mining of Non-Ferrous Metal Ores	4	15	1	4	4	71	19	47	34
6	Foods and Tobacco	4	4	8	16	11	57	18	30	52
7	Manufacture of Textile Products	1	3	4	22	13	58	9	51	40
8	Wearing apparel, leather, fur, down and related products	0	1	10	44	5	39	7	55	38
9	Processing of wood and Manufacture of Furniture	0	2	5	24	5	65	13	36	51
10	Paper Products and Articles for Culture, Education and Sports Activities	1	4	8	34	4	49	17	33	49
11	Processing of Petroleum, Coking and Nuclear Fuel	25	5	6	4	27	33	58	7	35
12	Manufacture of Chemical Products	6	4	6	21	11	52	15	40	45
13	Manufacture of non-ferrous metal products	1	6	3	12	7	71	10	51	39
14	Smelting and Rolling of metals	27	2	5	5	27	33	31	38	31
15	Manufacture of Metal Products	1	2	5	25	6	61	16	56	28
16	Manufacture of General Purpose and Special Purpose Machinery	5	6	5	18	7	59	24	42	35
17	Manufacture of Transport Equipment	10	5	11	16	15	42	16	18	66
18	Manufacture of Electrical Machinery and Equipment	1	2	15	27	11	44	13	57	30
19	Manufacture of Communication Equipment, computers and Other Electronic Equipment	2	2	45	31	6	15	7	68	25
20	Manufacture of Measuring Instruments and Machinery for Office Work	3	5	17	34	4	37	8	68	25
21	Handicrafts and other Manufacturing	0	1	4	43	4	48	7	53	40
22	Scrap and Waste	0	0	0	0	0	100	14	23	64
23	production and supply of Electricity and heat	40	36	2	3	5	15	97	0	3
24	Production and Supply of Gas	16	27	5	19	7	26			
25	Production and Supply of Water	12	66	0	5	0	16			
26	Construction industry	7	12	0	1	6	74			
27	Transportation and warehousing	1	31	2	0	0	66			
28	Post service	39	48	4	1	0	8			
29	IT industry	3	16	11	16	5	48			
30	wholesale and retailing	5	7	3	2	7	76			
31	Hotels and Catering Services	1	13	6	5	3	72			
32	Finance	8	9	0	2	3	79			
33	Real Estate	3	10	2	5	16	64			
34	Leasing and commerce service	3	19	1	5	2	71			
35	Research and test development industry	19	14	6	8	6	47			
36	Polytechnic Services	15	14	2	3	10	56			
37	Water, environment and public facilities	13	19	1	2	12	53			
38	Resident and Other Services	2	4	2	3	12	77			
39	Education	1	5	0	1	11	81			
40	Health and Social service	10	11	1	1	7	70			
41	Culture , Sports and entertainment	18	17	3	4	5	53	7	86	7
42	Public administration and social organization	1	4	0	0	7	87			
Total		7	9	3	8	8	65	19	44	36

Note: SL, SS, FL, FS, PL, and PS stand for large state-owned, small state-owned, large foreign, small foreign, large private, and small private firms, respectively.
Data Source: (1) 2008 China's NBS Firm Census. Data for Sector 27 (Transportation and warehousing) is inferred from information from 2008 NBS Economic Census and the railway sector in the 2007 135-sector I/O table. (2) Import data are from 2007 customs. (3) Total is the sum of all data for manufacturing, mining and services (agriculture is excluded).

are consistent with Kee and Tang (2016), who show that using firm-level data the increase in China's domestic content in exports in 2000s were mainly driven by exporters substituting domestic inputs for foreign inputs. However, it is the state-owned enterprises that experienced the sharpest increase in DVA contribution, followed by foreign firms that had its DVA share increased by 9.2%. Another fact revealed in Table A6 is that state-owned enterprises' DVA shares increased for exports by all firm groups. This is not observed for other firm groups. For instance, foreign firms' DVA shares increased only in their own exports but not for other firm groups.

The backward-linkage approach can be used to distribute sectoral DVA in exports into different firm groups' origins. Such an exercise provides another perspective to portray the cross-sector pattern of contributions by firm group. As reported in Table A7, a few sectors have more than 30% DVA originating from state-owned enterprises. In 2007, these sectors include "Mining and Washing of Coal" (state-owned enterprises' share in the sector's DVA = 39.98%), "Extraction of Petroleum and Natural Gas" (49.56%), "Mining of Non-Ferrous Metal Ores" (32.50), "Processing of Petroleum, Coking and Nuclear Fuel" (44.16), "Smelting and Rolling of Metals" (36.67), "Production and Supply of Electricity and Heat" (52.05). These are obviously "upstream" sectors that provide essential inputs to downstream exporters.

While state-owned enterprises appear to have a dominant position in some sectors, they are not the firm group that has the highest DVA shares for most sectors. It is the SME that often contribute more than 30% of DVA in most sectors. In fact, state-owned enterprises' DVA share exceeded 30% in only 13 sectors (out of 40) compared to 24 for SME. For example, SME's shares of DVA in

Table A5
Gross Exports and Distribution of the Source of DVA (Backward-linkage Approach).

2007		(1) Total		(2) State-owned	(3) Foreign	(4) Large Private	(5) Small and Medium Private
Gross Exports		**10199**		1231	5046	1028	2895
DVA Contribution (%)	State-owned	14.17		39.46 (24.03, 15.43)	10.11	15.38	10.08
	Foreign	18.05		9.81	28.11 (19.59, 8.52)	10.25	6.79
	Large Private	7.05		6.50	4.56	26.25 (19.42, 6.83)	4.80
	Small and Medium Private	28.84		18.30	15.56	20.66	59.37 (37.37, 22.00)
	Foreign VA	31.88		25.92	41.66	27.47	18.95
2010		Total	change relative to 07	State-owned	Foreign	Large Private	Small and Medium Private
Gross Exports		**11191**	**9.72**	1052	6340	1164	2635
DVA Contribution (%)	State-owned	16.27	14.77	50.32 (34.44, 15.89)	12.53	16.41	11.60
	Foreign	19.71	9.17	8.09	28.95 (19.77, 9.18)	9.82	6.46
	Large Private	7.46	5.81	5.54	5.18	27.78 (21.29, 6.49)	4.73
	Small and Medium Private	30.44	5.56	18.14	20.83	23.56	61.53 (34.59, 26.93)
	Foreign VA	26.12	-18.07	17.90	32.50	22.42	15.69

Note: Authors' estimation based on China's firm census data from 2008 and IO tables for 2007 and 2010, respectively. Numbers in brackets are direct and indirect DVA shares, respectively,

"Foods and Tobacco" and "Manufacture of Textile Products" are 60% and 52%, respectively. These findings suggest that SME have been playing an important role driving Chinese exports. This is consistent with the hypothesis that a lot of SME do not export directly, possibly because of high fixed export costs. Instead, they participate actively by supplying intermediate inputs and services to larger downstream exporters. In 2010, the number of sectors in which state-owned enterprises' share in DVA exceeded 30% actually dropped from 13 to 11. However, in sectors in which state-owned enterprises had the highest DVA share in 2007, state-owned enterprises' DVA shares have increased substantially. For example, in the "Mining and Washing of Coal" sector, state-owned enterprises' DVA share was 40% in 2007, which increased to 56% in 2010.

Appendix B. Extending the method by Antras et al. (2012) to measure industry upstreamness

To measure industry upstream based on our IO table with 6 sub-accounts, we need to modify the method proposed by Antras et al. (2012). First, we construct a 42x42 matrix for each firm group g1 with the following elements

$$\delta_{ij}^{g1} = \frac{\sum_p a_{ij}^{g1,g2} X_j^{g2} + E_{ij}^{g1}}{X_i^{g1}} \tag{A4}$$

where superscripts $g1, g2 \in \{SL, SS, FL, FS, PL, PS\}$ represent 6 firm groups, $a_{ij}^{g1,g2}$ is the IO coefficient between a pair of firm-type-sector discussed in Section 2 in the text. X_j^{g1} and X_j^{g2} are gross output by group g1 and g2 in sector j, respectively. E_{ij}^{g1} represents exports from sector i by firm group g1 used in sector j abroad.

When computing industry upstreamness, Antràs et al. (2012) assume that the share of imports (and exports) of sector i that is used by sector j is the same as the share of domestic intermediate inputs of sector i used by sector j. We improve upon their computation by relaxing both of these assumptions. First, in eq. (A4), we do not need to subtract imports from total intermediate inputs. It is because when we estimate our extended IO model, we already make the corresponding adjustment to deal with imported materials by having a separate A^m matrix. In other words, our IO coefficients, $a_{ij}^{g1,g2}$, do not include imported intermediate inputs. Thus, we do not need to make the proportionality assumptions as Antras et al. (2012) to exclude imports from domestic intermediate inputs in our computation of upstreamness.

Table A6
Gross Exports via Different Firm Types (Backward-linkage Approach)

		2007					2010				
Sector				Share in VAX (%)				Share in VAX (%)			VAX share > 30%
		SOE	FIE	LP	SME		SOE	FIE	LP	SME	
2	Mining and Washing of Coal	39.98	17.57	13.93	28.52	SOE	55.60	7.64	16.67	20.09	SOE
3	Extraction of Petroleum and Natural Gas	49.56	16.52	23.31	10.61	SOE	61.64	10.52	14.37	13.47	SOE
4	Mining of Ferrous Metal Ores	27.17	21.78	7.10	43.95	SME	27.19	12.95	7.15	52.71	SME
5	Mining of Non-Ferrous Metal Ores	32.50	24.00	12.91	30.58	SOE, SME	25.67	17.53	7.59	49.21	SME
6	Foods and Tobacco	15.56	17.32	7.25	59.86	SME	13.34	17.90	6.58	62.18	SME
7	Manufacture of Textile Products	15.34	22.60	10.51	51.55	SME	13.56	23.04	10.20	53.20	SME
8	Wearing apparel, leather, fur, down and related products	14.53	32.29	8.76	44.41	FIE. SME	13.90	28.71	9.08	48.32	SME
9	Processing of wood and Manufacture of Furniture	16.01	20.61	9.25	54.13	SME	19.13	26.47	8.76	45.64	SME
10	Paper Products and Articles for Culture, Education and Sports Activities	16.07	23.26	7.79	52.88	SME	17.12	36.05	7.27	39.56	FIE, SME
11	Processing of Petroleum, Coking and Nuclear Fuel	44.16	17.63	15.57	22.64	SOE	53.60	13.27	17.64	15.49	SOE
12	Manufacture of Chemical Products	20.80	26.23	10.61	42.36	SME	24.01	26.92	11.36	37.71	SME
13	Manufacture of non-ferrous metal products	22.76	16.48	9.15	51.60	SME	24.41	25.88	11.00	38.71	SME
14	Smelting and Rolling of metals	36.67	14.04	19.08	30.21	SOE, SME	38.12	16.25	15.62	30.01	SOE, SME
15	Manufacture of Metal Products	22.88	19.25	12.02	45.85	SME	25.36	29.05	11.80	33.79	SME
16	Manufacture of General Purpose and Special Purpose Machinery	20.98	26.46	11.43	41.14	SME	23.46	29.47	12.31	34.77	SME
17	Manufacture of Transport Equipment	25.58	29.49	15.85	29.07	None	24.71	29.44	15.25	30.60	SME
18	Manufacture of Electrical Machinery and Equipment	23.09	28.44	14.10	34.37	SME	22.80	31.43	12.87	32.90	FIE, SME
19	Manufacture of Communication Equipment, computers and Other Electronic Equipment	16.17	55.43	8.09	20.31	FIE	17.14	42.92	9.35	30.59	FIE, SME
20	Manufacture of Measuring Instruments and Machinery for Office Work	25.39	33.29	13.79	27.53	FIE	18.58	44.16	9.59	27.66	FIE
21	Handicrafts and other Manufacturing	17.25	26.26	11.71	44.78	SME	10.84	41.80	6.93	40.44	FIE, SME
22	Scrap and Waste	1.94	1.25	0.78	96.03	SME	-	-	-	-	None
23	production and supply of Electricity and heat	52.05	13.59	11.56	22.80	SOE	64.01	7.15	6.44	22.40	SOE
24	Production and Supply of Gas	-	-	-	-	None	-	-	-	-	None
25	Production and Supply of Water	-	-	-	-	None	-	-	-	-	None
26	construction industry	29.70	17.39	13.40	39.51	SME	25.31	9.70	9.75	55.24	SME
27	Transportation and warehousing	32.17	7.58	5.00	55.25	SOE, SME	38.32	9.12	6.02	46.54	SOE, SME
28	Post service	30.21	30.79	12.14	26.86	SOE, FIE	65.71	11.71	5.53	17.05	SOE
29	IT industry	30.41	31.96	13.92	23.70	SOE, FIE	27.80	36.17	9.23	26.80	FIE
30	wholesale and retailing	13.85	7.10	4.96	74.09	SME	23.48	8.82	8.12	59.58	SME
31	Hotels and Catering Services	19.21	16.08	8.29	56.42	SME	19.16	13.18	6.08	61.58	SME
32	Finance	34.88	16.08	10.94	38.10	SOE, SME	27.85	6.97	2.58	62.61	SME
33	Real Estate	-	-	-	-		-	-	-	-	-
34	Leasing and commerce service	22.12	15.43	8.40	54.05	SME	30.00	15.85	6.87	47.28	SOE, SME
35	Research and test development industry	33.83	22.61	15.96	27.60	SOE	38.35	14.94	10.52	36.19	SOE, SME
36	Polytechnic Services	-	-	-	-	None	-	-	-	-	None
37	Water, environment and public facilities	-	-	-	-	None	-	-	-	-	None
38	Resident and Other Services	26.16	21.35	12.79	39.70	SME	15.45	10.26	10.22	64.07	SME
39	Education	26.88	20.64	14.81	37.67	SME	18.69	10.46	16.89	53.95	SME
40	Health and Social service	31.85	20.85	14.58	32.72	SOE, SME	31.79	12.40	14.20	41.61	SOE, SME
41	Culture , Sports and entertainment	34.84	21.85	14.51	28.80	SOE	48.37	9.05	4.51	38.08	SOE, SME

Notes: Authors' estimation based on China's firm census data from 2008 and IO tables for 2007 and 2010, respectively.

Second, when computing E_{ij}^{g1}, we use data of exported intermediate inputs at the sector-pair level (ij) from China's customs. To assign exported intermediate inputs to each firm group, we use the share of each supplier's firm group in domestic inter-sector transaction volume (i.e., $\frac{\sum_{g2} a_{ij}^{g1,g2}}{\sum_{g1,g2} a_{ij}^{g1,g2}}$) as the weight. For sectors that we do not have exported intermediate inputs from China's Customs (most of them are service sectors), we follow Antras et al. (2012) and make the same proportionality assumption to obtain E_{ij}^{g1}.

We also adjust for the change in inventory at the sector level carefully. First, we obtain inventory by firm group and sector. Then following the approach proposed by Antràs et al., (2012), we subtract inventory from X_i^{g1} in eq. (A4). After obtaining a 42x42 block matrix of δ_{ij}^{g1}, we use eq. (4) in Antràs et al. (2012) to compute upstreamness by firm-group-sector.

Table A7
Industry Upstream Index

		2007					2010				
		All	By Type				All	By Type			
	Industry		SOE	LFIE	LGE	SME		SOE	LFIE	LGE	SME
3	Extraction of Petroleum and Natural Gas	5.09	6.02	5.31	4.99	4.39	5.22	6.31	4.91	5.32	4.22
4	Mining of Ferrous Metal Ores	5.03	5.80	5.79	5.27	4.30	5.04	5.66	5.84	5.24	4.68
2	Mining and Washing of Coal	4.90	5.72	5.35	4.91	3.98	5.13	5.86	5.09	5.04	4.68
23	production and supply of Electricity and heat	4.46	5.09	4.69	4.35	3.75	4.60	5.31	4.30	4.14	3.85
11	Processing of Petroleum, Coking and Nuclear Fuel	4.27	5.22	4.77	4.04	3.59	4.38	5.57	5.08	4.19	4.06
14	Smelting and Rolling of metals	3.98	4.86	4.73	4.27	3.22	3.95	5.00	4.92	4.31	3.52
12	Manufacture of Chemical Products	3.83	3.70	4.20	3.92	3.89	4.02	3.65	4.54	4.50	4.30
5	Mining of Non-Ferrous Metal Ores	3.77	3.78	4.16	3.70	3.92	3.94	3.84	4.86	3.94	3.98
24	Production and Supply of Gas	3.35	3.70	3.75	3.56	3.01	2.92	4.25	3.10	4.87	2.11
10	Paper Products and Articles for Culture, Education and Sports Activities	3.32	3.89	3.65	3.90	2.97	3.76	3.50	4.08	4.24	4.14
27	Transportation and warehousing	3.31	3.82	4.34	4.08	2.47	3.46	4.13	4.68	4.53	3.08
32	Finance	3.28	4.42	4.54	4.22	2.32	3.49	4.69	5.01	4.84	3.04
15	Manufacture of Metal Products	3.27	3.88	4.14	3.68	2.57	3.60	3.45	4.34	4.20	3.48
25	Production and Supply of Water	3.22	3.48	3.72	3.72	2.75	2.51	2.28	4.20	4.75	2.39
28	Post service	3.21	3.54	3.62	3.45	2.83	3.45	3.84	4.79	4.60	3.56
34	Leasing and commerce service	3.14	3.80	3.93	3.66	2.33	3.38	4.51	4.77	4.62	2.78
36	Polytechnic Services	3.11	3.28	3.54	3.12	2.56	3.15	3.56	4.74	3.87	2.46
7	Manufacture of Textile Products	3.06	2.96	4.01	3.14	2.76	3.40	3.67	3.12	4.38	3.54
16	Manufacture of General Purpose and Special Purpose Machinery	2.90	3.98	3.73	3.46	2.04	2.93	4.39	3.67	3.46	2.37
13	Manufacture of non-ferrous metal products	2.73	2.89	3.21	2.80	2.65	2.85	2.69	4.45	3.63	2.67
17	Manufacture of Transport Equipment	2.72	3.36	3.02	3.02	2.14	2.46	3.06	2.87	2.69	2.15
18	Manufacture of Electrical Machinery and Equipment	2.71	3.94	3.84	2.92	1.79	2.71	4.85	3.62	3.03	2.12
9	Processing of wood and Manufacture of Furniture	2.65	3.27	3.18	3.31	2.11	2.90	4.40	3.41	3.74	2.80
30	wholesale and retailing	2.64	3.60	4.01	3.52	1.66	2.84	4.09	4.72	4.22	2.23
29	IT industry	2.46	2.94	2.69	2.93	1.96	2.34	3.11	2.72	3.58	1.84
38	Resident and Other Services	2.44	3.45	3.57	3.29	1.46	2.43	4.65	4.99	4.48	1.83
31	Hotels and Catering Services	2.43	3.59	3.69	3.51	1.46	2.81	4.42	4.83	4.56	2.14
6	Foods and Tobacco	2.42	2.85	2.44	2.52	2.09	2.54	3.15	2.73	2.73	2.34
35	Research and test development industry	2.41	2.90	2.36	2.70	2.32	2.28	2.26	3.65	3.35	1.86
20	Manufacture of Measuring Instruments and Machinery for Office Work	2.36	2.90	3.11	2.28	1.86	2.91	4.59	2.67	3.73	3.44
21	Handicrafts and other Manufacturing	2.29	2.50	2.69	2.72	1.84	3.12	4.88	3.94	4.32	2.77
41	Culture , Sports and entertainment	2.19	2.48	2.26	2.58	2.02	2.33	2.35	4.76	4.42	1.99
19	Manufacture of Communication Equipment, computers and Other Electronic Equipment	2.17	3.38	3.91	2.54	2.10	2.62	4.80	2.56	3.90	3.38
37	Water, environment and public facilities	1.95	1.97	2.09	1.96	1.70	1.86	1.91	3.95	3.12	1.30
8	Wearing apparel, leather, fur, down and related products	1.85	2.97	1.92	2.37	1.39	2.05	4.89	2.34	3.32	1.66
33	Real Estate	1.67	2.65	2.58	1.53	1.22	1.60	3.41	3.00	1.46	1.22
40	Health and Social service	1.26	1.50	1.48	1.48	1.08	1.20	1.34	3.03	1.37	1.05
39	Education	1.20	1.43	1.46	1.31	1.05	1.09	1.39	1.77	1.11	1.02
26	Construction industry	1.06	1.08	1.24	1.08	1.02	1.06	1.10	2.83	1.09	1.02
42	Public administration and social organization	1.02	1.05	1.10	1.05	1.01	1.03	1.11	2.50	1.13	1.01

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