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Trade in Factor Income and the US-China Trade Balance

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Abstract

Numerous the US multinational enterprises sold considerable amounts of products, which were “made” in China or third countries, to China’s domestic consumers, but these sales were not counted as the US exports to China. We propose a beyond-border-type measure, “trade in factor income,” that defines the US-owned factor-income induced by China’s final demand as the US export to China. Based on this measure, we find that the conventional cross-border trade statistics averagely leads to 17.4-32.0% overestimation of the US-China trade deficit (2005-2016). Our new measure helps a great transformation of trade measures from the territory-based “made in” label to income-based “created by” label.

Keywords: trade in factor income, trade in value added, trade balance, global value chain, the US-China trade

JEL classification: F6, F10, F21, F23, D57

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Trade in Factor Income and the US-China Trade Balance

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Abstract (longer version):

One of the most important objectives of exports is to derive income from foreign markets. However, conventional cross-border trade statistics may lead to a misunderstanding of the nature of international trade, which is characterized by multinational enterprises dominating global value chains. For example, numerous the US multinational enterprises sold considerable amounts of products, which were "made" or "assembled" in China or third countries through FDI channels, to China's domestic consumers, but these sales were not counted as the US exports to China by conventional trade measures. This study proposes a novel beyond-border-type trade measure, "trade in factor income (TiFI)," that is based on an inter-country-input-output model in consideration of firm ownership heterogeneity and FDI channels. In the model, the US-owned factor income induced by China's final demand is defined as the US export to China. Based on TiFI, we find that, on average, from 2005 to 2016, the US-China trade deficit was 68.0% of that of the traditional gross trade statistics approach and 82.6% of the trade in value-added approach. This new measure enhances our understanding of the transformation of trade from the territory-based "made in" label to income-based "made for" or "created by" label in the era of global value chains.

Keywords: trade in factor income, trade in value added, trade balance, global value chain, the US-China trade

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In 2018, the US had a 420 billion US$ trade deficit with China, which was approximately half of its total trade deficit in that year. The huge and persistent trade deficit triggered the ongoing trade war between them—the two largest economies in the world. The apparent trade deficit might be a justifiable reason for the US to wage the trade war to increase access of its goods to China. However, a critical question is whether current trade statistics, which are compiled based on the classic "cloth-for-wine" trade, present the true picture of the trade balance between the two countries. Most of China's exports are manufactured and traded along global value chains (GVCs) and contain a large content of foreign value-added, which has significantly inflated China's exports to and trade surplus with the US.

We use Xing and Detert's (2010) case study of iPhone 3G exports from China to the US as an example. iPhone contributed 1.9 billion US$ to the US-China gross trade deficit in 2009. However, from a value-added perspective, China contributed only 3.6% to this deficit. Johnson and Noguera (2012) and Koopman et al. (2014) showed that the US-China trade balance would be smaller when trade in value-added (TiVA), which is a newly developed method that is based on inter-country-input-output (ICIO) models, is used to measure it. The WTO report (WTO, 2017) also showed that when the TiVA approach is used, the China-US trade imbalance is 79% of what is calculated with gross trade volumes in 2008 and less than one-fifth for the ICT sector.

Although studies have improved our understanding of trade in an age of GVCs, they have not touched on issues about the gains of multinational enterprises that organize and manage the operations of GVCs. According to conventional trade statistics, China has a massive trade surplus with the US, but based on recent firm-level analyses (Zhang et al., 2018; IMF, 2021), the US firms, including its affiliates worldwide, sold more goods and services to China than what China's firms sold to the US in 2017.

Selling made in the US goods in China is one way that the US exports to China. The unprecedented liberalization of foreign direct investment (FDI) offers another means of selling the US goods to Chinese consumers. To date, the massive number of the US brand goods produced by the US invested firms in China is sold in the Chinese market (e.g. Tesla's China-made Model 3 vehicles). However, according to the rules of national accounting, those sales are treated as China's domestic transaction (none is regarded as the US exports to China in conventional international trade statistics), and profits associated with those sales are also counted as part of China's GDP. Part of those sales represent returns on both tangible and intangible assets of the US affiliates. If their products are shipped to the Japanese market, they will be treated as China's exports to Japan in conventional trade statistics (none will be regarded as the US export to Japan). Current trade statistics are defined by the territory (relating to the border of the country) rather than the ownership of factor income, which causes the problem of “what you see (domestic sales or trade flows) is not what you get (income)” in examining economic transactions.

One of the important objectives of exports is to derive income from foreign markets. Exporting products directly to foreign countries, building factories abroad, or outsourcing production to foreign contact manufacturers are different business models but have the same objective of making profits. In terms of income generation, they are not different. FDI combined with intellectual properties is a popular means of earning returns on intangible assets in the global market. For example, an estimated 85% of the S&P 500's (the 500 largest firms on U.S. stock markets, most of which are involved internationally) market capitalization comes from intangible assets (Reuters, 2020). Inspired by these facts, this study proposes a new concept of exports, “trade in factor income (TiFI).” TiFI is based on the ownership of factor income. Moreover, this study develops a new accounting system of international trade to trace factor incomes, which mainly comprise labor compensation and return to capital, embodied in trade at country, sector, and bilateral levels by firm ownership to have a better understanding of the actual magnitude of the US-China trade balance and the income distribution pattern in GVCs.

TiFI is based on a new ICIO model that includes firm ownership information and FDI channels. TiFI employs both the “tear down” type case studies, with explicit consideration of multinationals' investment and trade activities worldwide, and the logic of ICIO based TiVA measure to remove double counting. More importantly, we extend the concept of commercial presence (Mode 3) used in measuring services trade (WTO, 1994)[1] to factor incomes embodied in both goods and services.

Our measure mainly assigns factor income of multinationals that produce factory goods[2] outside their home countries through FDI channels (we refer to this phenomenon as “hidden trade”) rather than multinationals that are “factoryless” goods producers (FGPs)[3], such as iPhone's producer, Apple. This is because most of Apple's profit embodied in China-assembled products are not recorded as part of China's GDP (de Haan and Haynes, 2018; Brothers, 2014). The emergence of FGPs has also caused the so-called “missing export”

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[1] Services supplied by a WTO member through commercial presence in the territory of any other member, e.g., the service is provided in country A by a locally established affiliate, subsidiary, or representative office of a foreign-owned and foreign-controlled company (e.g., bank, hotel group, and construction company).

[2] “Factory-goods” refer to products made by non-factoryless goods producers, which refer to multinationals that fully or partly own a factory abroad they use to produce goods and services through FDI channels.

[3] According to the definition by Eurostat, a FGP is an extreme case of goods sent abroad for processing, where the physical transformation of the goods is 100% outsourced. A FGP arrangement occurs when a resident firm owns the intellectual property, such as the technology, know-how, and product design, used in the production process but fully outsource the material transformation process (either in the same country or abroad) required for production. The thrust of this arrangement is that the control over the outcome of the production process and ownership and provision of the intellectual property product (IPP) inputs coincide with the economic ownership of the final output (https://ec.europa.eu/eurostat/web/economic-globalisation/globalisation-macroeconomic-statistics/global-production-arrangements/factoryless-goods-producers).

problem discussed by Xing (2020), who argued that "if the value-added of Apple intellectual property and services embodied in all Apple products sold to the foreign consumers were counted as part of US exports, the US-China trade deficit in 2015 would decrease by 5.2%." Therefore, by combining our TiFI-based measure for multinationals that produce factory goods via FDI with Xing's (2020) measure for multinationals that are FGPs, we get a clearer understanding of the real size of the US-China trade balance.

Our main conclusion, which is based on real data, shows that when treating the US-owned factor incomes induced (absorbed) by China's final demand in both domestic transaction and international trade as the US exports to China (we define this as bilateral TiFI) and China-owned factor incomes induced by the US final demand as China's exports to the US, the US-China trade deficit in factor income terms from 2005 to 2006 is on average 68.0% of that of the traditional gross trade statistics approach and 82.6% of the conventional TiVA approach. This huge difference in measuring the US-China trade balance indicates that the existing trade measures do not correctly capture the essential features of the 21st-century type trade (Baldwin et al., 2014), which is characterized as multinationals-dominated GVCs, thereby making it difficult to truly understand "who gains what from where" through complex international trade and investment in the globalized world economy.

I. The Concept of Trade in Factor Income

Using the US-China trade as an example, TiFI is defined as follows:

The US exports to China in factor income terms is the US-owned factor incomes induced by China's final demand; the US-owned factor incomes include the return to tangible and intangible assets of the American-owned firms located in the US and outside the US via FDI channels, the US domestic labor compensation, and the net taxes of the US government.

China's exports to the US in factor income terms is China-owned factor incomes induced by the US final demand; China-owned factor incomes include the return to tangible and intangible assets of the Chinese-owned firms located in China and outside China via FDI channels, China's domestic labor compensation, and the net taxes of the Chinese government.

Table 1. The concept of trade in factor income and its relation with gross term trade and trade in value-added measures

Firm Location / Firm ownership	Located in the US			Located in China			Located in Third Countries		
American-owned Firms	Labor Compensation 1	Net taxes on products 2	Return to Capital 3	Labor Compensation *	Net taxes on products *	Return to Capital 4 *	Labor Compensation *	Net taxes on products *	Return to Capital 5 *
Foreign-owned Firms (including Chinese-owned Firms)	Labor Compensation 6	Net taxes on products 7	Return to Capital 8	Labor Compensation *	Net taxes on products *	Return to Capital *	Labor Compensation *	Net taxes on products *	Return to Capital *

*Note: * refers to the foreign value-added and double counting embodied in the US gross exports to China; Net taxes refers to taxes minus subsidies on products.*

The US exports to China measured in different terms:

Gross Exports = 1 + 2 + 3 + 6 + 7 + 8 +*

TiVA = 1 + 2 + 3 + 6 + 7 + 8

TiFI =1 + 2 + 3 + 4 + 5 + 6 + 7

Using two types of firms, the US- and foreign-owned firms, in three locations, the US, China, and third countries as an example, we use Table 1 to explain how we define the US exports to China in TiFI terms and its relationship with TiVA and the gross trade statistics. In an input-output (IO) system, value-added in factor income comprises labor compensation, returns to capital (including both tangible and intangible assets), and net taxes (taxes minus subsidies on products). In gross terms, the US exports (**1 + 2 + 3 + 6 + 7 + 8 +***) include the domestic value-added of the US- (**1 + 2 + 3**) and foreign-owned firms (**6 + 7 + 8**) in the US and foreign value-added and double-counted parts of intermediates embodied in those exports (*****). In value-added terms, the US exports (**1 + 2 + 3 + 6 + 7 + 8**) are the pure domestic value-added (**1 + 2 + 3 + 6 + 7 + 8**) without any foreign value-added and double counting involved. In factor income terms, the US exports (**1 + 2 + 3 + 4 + 5 + 6 + 7**) include domestic value-added of the US-owned firms (**1 + 2 + 3**), returns to capital of the US-owned firms in China (**4**) and third countries (**5**), labor compensation of foreign-owned firms in the US (**6**), and net taxes on products of foreign-owned firms in the US (**7**).

The treatment of factor incomes, especially the return to capital associated with trade, is different from the concept of national income in the national accounting system. For example, in definition, the return to capital of the US-owned firms in China is part of China's GDP; most of this capital gain may be added to China's gross national income, but they are widely owned and controlled by the US-owned firms. Some of this return to capital may be reinvested in China or repatriated to the US to pay the cost of using intangible capital (e.g., R&D, superior brand value, sophisticated distribution strategies, and organizational capital (Setser, 2017)) or to pay dividends to stockholders. However, they are extremely difficult to be traced at country, sector, and bilateral levels by firm ownership using the concept of pure national income due to the complex structure of stockholder and the problem caused by transfer pricing (Garcia-Bernardo et al., 2017).

Compared with those of the traditional gross trade statistics, the conventional TiVA, firm-level survey data on multinationals, and individual firm's case studies in measuring bilateral trade balance (Table 2), the originality and innovation of TiFI are obvious. The limitation of the traditional gross statistics approach is double counting, with no explicit consideration of factor income. The conventional TiVA approach solves the double counting problem at country sector levels, but it highly relies on the GDP concept, without explicit consideration of factor income by firm ownership. The firm-level survey data on multinationals' sales can be used to partly trace factor income but has the double counting problem. The "tear down" type firm- and product-based case studies provide a very intuitive but partial solution for double counting and FGP-related “missing exports” problems since they cannot trace value-added and factor income in the upstream and downstream of an entire value chain. TiFI covers both cross-border and cross-firm boundary transactions, without any double counting, thus can bridge value-added to factor income by firm ownership (excluding FGPs) and, like traditional trade statistics and TiVA, it can offer a universal accounting framework.

Table 2. Advantages of measuring bilateral trade balance in different terms

	Cross-border transaction	Cross-firm-boundary transaction	Can avoid double counting problem	Can solve the “hidden trade” problem	Can solve the “missing export” problem	Universal accounting framework
Traditional trade statistics in gross terms (e.g., UN Comtrade)	✓	✕	✕	✕	✕	✓
Firm-level transaction data (e.g., BEA’s data on multinationals)	✓	✓	✕	✓̶	✓̶	✕
The conventional territory-based TiVA (e.g., ICIO models)	✓	✕	✓	✕	✕	✓
Firm- and product-level case studies (e.g., iPhone case studies)	✓̶	✓̶	✓̶	✓̶	✓̶	✕
TiFI (our method)	✓	✓	✓	✓	✕	✓

II. Model and Data

Our method is based on the work of Leontief (1936). Leontief demonstrated that the complex relationships between different industries in various countries can be expressed as various inter-industry and cross-country transactions organized into chessboard-type matrices, which is known as IO tables. Each column in the table represents the inputs required from other industries (including imports and direct value-added) to produce a given amount of a product. After normalization, the technical coefficient table represents the amount and type of intermediate inputs needed to produce a unit of gross output. Using these coefficients, the gross output in all stages of production that is needed to produce a unit of final products can be estimated using the Leontief inverse. When the output associated with a particular level of final demand is known, the total value-added throughout the (global) economy can be estimated by multiplying these output flows with the value-added ratio (the amount of value-added per unit of gross output) in each country/industry.

Following Leontief's ideas, TiVA, which is a measure of bilateral trade, was recently developed by Johnson and Noguera (2012) and Koopman et al. (2014). Their novel contribution is to avoid the double counting in using traditional gross trade statistics to measure bilateral trade, thus making the consistent tracing of value-added creation, transfer, and distribution across countries available in an inter-country input-output (ICIO) framework.

Table 3. The layout of the OECD AMNE ICIO tables

Outputs / Inputs		Intermediate Use							Final Demand				Total Output
		1		2		⋯	G		1	2	⋯	G	
Intermediate Inputs	1	Z_{DD}^{11}	Z_{DF}^{11}	Z_{DD}^{12}	Z_{DF}^{12}	⋯	Z_{DD}^{1g}	Z_{DF}^{1g}	Y_{D}^{11}	Y_{D}^{12}	⋯	Y_{D}^{1g}	X_{D}^{1}
		Z_{FD}^{11}	Z_{FF}^{11}	Z_{FD}^{12}	Z_{FF}^{12}	⋯	Z_{FD}^{1g}	Z_{FF}^{1g}	Y_{F}^{11}	Y_{F}^{12}	⋯	Y_{F}^{1g}	X_{F}^{1}
	2	Z_{DD}^{21}	Z_{DF}^{21}	Z_{DD}^{22}	Z_{DF}^{22}	⋯	Z_{DD}^{2g}	Z_{DF}^{2g}	Y_{D}^{21}	Y_{D}^{22}	⋯	Y_{D}^{2g}	X_{D}^{2}
		Z_{FD}^{21}	Z_{FF}^{21}	Z_{FD}^{22}	Z_{FF}^{22}	⋯	Z_{FD}^{2g}	Z_{FF}^{2g}	Y_{F}^{21}	Y_{F}^{22}	⋯	Y_{F}^{2g}	X_{F}^{2}
	⋮	⋮	⋮	⋮	⋮	⋱	⋮	⋮	⋮	⋮	⋱	⋮	⋮
	G	Z_{DD}^{g1}	Z_{DF}^{g1}	Z_{DD}^{g2}	Z_{DF}^{g2}	⋯	Z_{DD}^{gg}	Z_{DF}^{gg}	Y_{D}^{g1}	Y_{D}^{g2}	⋯	Y_{D}^{gg}	X_{D}^{g}
		Z_{FD}^{g1}	Z_{FF}^{g1}	Z_{FD}^{g2}	Z_{FF}^{g2}	⋯	Z_{FD}^{gg}	Z_{FF}^{gg}	Y_{F}^{g1}	Y_{F}^{g2}	⋯	Y_{F}^{gg}	X_{F}^{g}
Value-added		Va_{D}^{1}	Va_{F}^{1}	Va_{D}^{2}	Va_{F}^{2}	⋯	Va_{D}^{g}	Va_{F}^{g}					
Total input		$(X_{D}^{1})'$	$(X_{F}^{1})'$	$(X_{D}^{2})'$	$(X_{F}^{2})'$	⋯	$(X_{D}^{g})'$	$(X_{F}^{g})'$					

Note: The ICIO data used is from the OECD analytical AMNE database (Cadestin et al., 2018), where firms are split according to their ownership (D: domestic-owned firms and F: foreign-owned firms) from 2005 to 2016, with G=60 economies (including the "rest of the world" as one economy) and N=34 sectors in the ISIC Rev. 4 classification at the basic price.[4] *Foreign-owned firms are defined as foreign affiliates that have at least 50% foreign ownership, and domestic-owned firms include domestic multinationals (domestic firms with foreign affiliates) and domestic firms that are not involved in international investment.* $\mathbf{Z}_{FD}^{12}$ *is the N by N matrix, representing the exports of intermediate inputs produced by foreign-owned firms in country 1 used by country 2's domestic-owned firms.* $\mathbf{Y}_{F}^{12}$ *is the N by 1 vector representing the exports of final products produced by foreign-owned firms in country 1 used by country 2.* $\mathbf{X}$ *is the 2GN by 1 column vector of output;* $\mathbf{Va}$ *is the 1 by 2GN row vector of value-added. For detailed information about the country or regional sector classification, on can refer to Appendices 1 and 2.*

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[4] The main data sources used in compiling the OECD AMNE–ICIO tables include the OECD–ICIO tables, OECD–AMNE statistics, national accounts, other national sources, Trade by Enterprise Characteristics, Services Trade by Enterprise Characteristics, and micro-level databases.

To estimate the bilateral TiFI, we follow the logic of TiVA and develop a new ICIO model that considers firm ownership heterogeneity and FDI channels. In the first stage of our estimation of TiFI, we consider an ICIO model with G countries, N sectors, and 2 types of firms (D: domestic-owned firms; F: foreign-owned firms), which is consistent with the layout of the available OECD AMNE ICIO tables (see Table 3 and its note). In the second stage, we estimate the bilateral sectoral FDI stock data to measure the contribution of factor income by country of origin of the foreign-owned firms under some technology assumptions (see Appendix 1).

Based on our definition of TiFI, country r's factor income induced by country s' final demand ($\mathbf{TiFI}^{rs}$) can be given as follows:

$$\mathbf{TiFI}^{rs} = \mathbf{TiVA}_{\mathbf{D}}^{rs} + \mathbf{TiFI\_L}_{\mathbf{F}}^{rs} + \mathbf{TiFI\_T}_{\mathbf{F}}^{rs} + \mathbf{TiFI\_C}_{\mathbf{F=r}}^{ss} + \mathbf{TiFI\_C}_{\mathbf{F=r}}^{ts(t\neq r,s)}, \quad (1)$$

where $\mathbf{TiVA}_{\mathbf{D}}^{rs}$ is country r's domestic-owned firms' value-added induced by country s' final demand, which comprises three parts:

$$\mathbf{TiVA}_{\mathbf{D}}^{rs} = \mathbf{TiFI\_L}_{\mathbf{D}}^{rs} + \mathbf{TiFI\_C}_{\mathbf{D}}^{rs} + \mathbf{TiFI\_T}_{\mathbf{D}}^{rs}. \quad (2)$$

$\mathbf{TiFI\_L}_{\mathbf{D}}^{rs}$, $\mathbf{TiFI\_C}_{\mathbf{D}}^{rs}$, and $\mathbf{TiFI\_T}_{\mathbf{D}}^{rs}$ are country r's induced domestic-owned firms' labor compensation (L), return to capital (C), and net taxes (N) by country s' final demand, respectively, which can be given as follows:

$$\mathbf{TiFI\_L}_{\mathbf{D}}^{rs} = \mathbf{l}_{\mathbf{D}}^{r} \textstyle\sum_{t}(\mathbf{B}_{\mathbf{DD}}^{rt}\mathbf{Y}_{\mathbf{D}}^{ts} + \mathbf{B}_{\mathbf{DF}}^{rt}\mathbf{Y}_{\mathbf{F}}^{ts}), \quad (3)$$
$$\mathbf{TiFI\_C}_{\mathbf{D}}^{rs} = \mathbf{c}_{\mathbf{D}}^{r} \textstyle\sum_{t}(\mathbf{B}_{\mathbf{DD}}^{rt}\mathbf{Y}_{\mathbf{D}}^{ts} + \mathbf{B}_{\mathbf{DF}}^{rt}\mathbf{Y}_{\mathbf{F}}^{ts}), \quad (4)$$
$$\mathbf{TiFI\_T}_{\mathbf{D}}^{rs} = \mathbf{n}_{\mathbf{D}}^{r} \textstyle\sum_{t}(\mathbf{B}_{\mathbf{DD}}^{rt}\mathbf{Y}_{\mathbf{D}}^{ts} + \mathbf{B}_{\mathbf{DF}}^{rt}\mathbf{Y}_{\mathbf{F}}^{ts}), \quad (5)$$

where $\mathbf{l}_{\mathbf{D}}^{r} = \mathbf{L}_{\mathbf{D}}^{r}/\mathbf{X}_{\mathbf{D}}^{r}$, $\mathbf{c}_{\mathbf{D}}^{r} = \mathbf{C}_{\mathbf{D}}^{r}/\mathbf{X}_{\mathbf{D}}^{r}, \mathbf{n}_{\mathbf{D}}^{r} = \mathbf{N}_{\mathbf{D}}^{r}/\mathbf{X}_{\mathbf{D}}^{r}$ are 1 by N row vectors indicating the share of country r's domestic-owned firms' labor compensation ($\mathbf{L}_{\mathbf{D}}^{r}$), return to capital ($\mathbf{C}_{\mathbf{D}}^{r}$), and net taxes ($\mathbf{N}_{\mathbf{D}}^{r}$) in their output ($\mathbf{X}_{\mathbf{D}}^{r}$) by sector, respectively. **/**: is an elementwise vector division operator. $\mathbf{B}_{\mathbf{DD}}^{rt}$ is the N by N sub-matrix of the 2GN by 2GN global Leontief inverse $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$, indicating the induced output of country r's domestic-owned firms by a unit final demand of products made by country t's domestic-owned firms; $\mathbf{B}_{\mathbf{FD}}^{rt}$ is the sub-matrix of the global Leontief inverse $\mathbf{B}$, indicating the induced output of country r's foreign-owned firms by a unit final demand of products made by country t's domestic-owned firms; $\mathbf{Y}_{\mathbf{D}}^{ts}$ is N by 1 column vector indicating country s' final demand of products made by country t's domestic-owned firms; $\mathbf{Y_F^{ts}}$ is N by 1 column vector indicating country s' final demand of products made by country t's foreign-owned firms.

$\mathbf{TiFI\_L_F^{rs}}$ in Eqution (1) is country r-located foreign-owned firms' labor compensation induced by country s' final demand; $\mathbf{TiFI\_T_F^{rs}}$ is country r-located foreign-owned firms' net tax induced by country s' final demand; $\mathbf{TiFI\_C_{F=r}^{ss}}$ is country s-located country r-owned firms' return to capital induced by country s' final demand; $\mathbf{TiFI\_C_{F=r}^{ts(t\neq r,s)}}$ is third country t $(t \neq r, s)$-located country r-owned firms' return to capital induced by country s' final demand, which is given as follows:

$$\mathbf{TiFI\_L_F^{rs}} = \mathbf{l_F^r} \textstyle\sum_t (\mathbf{B_{FD}^{rt}} \mathbf{Y_D^{ts}} + \mathbf{B_{FF}^{rt}} \mathbf{Y_F^{ts}}), \quad (6)$$

$$\mathbf{TiFI\_T_F^{rs}} = \mathbf{n_F^r} \textstyle\sum_t (\mathbf{B_{FD}^{rt}} \mathbf{Y_D^{ts}} + \mathbf{B_{FF}^{rt}} \mathbf{Y_F^{ts}}), \quad (7)$$

$$\mathbf{TiFI\_C_{F=r}^{ss}} = \mathbf{c_{F=r}^{s}} \textstyle\sum_t (\mathbf{B_{FD}^{st}} \mathbf{Y_D^{ts}} + \mathbf{B_{FF}^{st}} \mathbf{Y_F^{ts}}), \quad (8)$$

$$\mathbf{TiFI\_C_{F=r}^{ts(t\neq r,s)}} = \mathbf{c_{F=r}^{t}} \textstyle\sum_u (\mathbf{B_{FD}^{tu}} \mathbf{Y_D^{us}} + \mathbf{B_{FF}^{tu}} \mathbf{Y_F^{us}}). \quad (9)$$

In Equation (8),

$$\mathbf{c_{F=r}^{s}} = \boldsymbol{\delta}_\mathbf{r}^\mathbf{s} \mathbf{c_F^s}, \quad (10)$$

where $\boldsymbol{\delta}_\mathbf{r}^\mathbf{s}$ is the share of country s-located country r-owned firms' FDI stock in the total inward FDI stock of country s by sector; $\mathbf{c_F^s} = \mathbf{C_F^s}/\mathbf{X_F^s}$ is the 1 by N vector, indicating the share of country s-based foreign-owned firms' return to capital ($\mathbf{C_F^s}$) in its output ($\mathbf{X_F^s}$) by sector. Since there is no available, relevant, and comparable international data to show the return to capital of a specific country-owned firms (FDI home country) that invest in another country (FDI host country) at the sector level, Equation (10) assumes that more FDI stock, more return to captial the investing firms gain. In the same manner, we also assume $\mathbf{c_{F=r}^{t}} = \boldsymbol{\delta}_\mathbf{r}^\mathbf{t} \mathbf{c_F^t}$.

In addition, there is no available, relevant, and comparable international data to show the production function of FDI firms by country of origin at the sector level. From the OECD AMNE ICIO data, we can only derive the average production function (the input structure of intermediates) of foreign-owned firms at the sector level as a whole. Since different country may bring or use different technologies to invest abroad, we use the following pools (combinations) of technology assumptions as the boundary of our estimation of bilateral TiFI.

Technology Assumption 1 (TA1: baseline): the FDI home country (investor) uses an average technology as other FDI home countries use in the FDI host country (investee); TA1 can be regarded as a type of technological convergence due to the market competition of FDI home countries.

Technology Assumption 2 (TA2): the FDI home country (investor) brings its domestic technology to the host country (investee).

Technology Assumption 3 (TA3): the FDI home country (investor) uses the same technology as the host country (investee) uses. TA3 can be regarded as a type of technological convergence between FDI home and host countries due to market competition or spillover of technology.

We believe that, in practice, technologies used (brought in) by firms of an FDI home country in the host country depend on many factors (e.g., competition, market strategy, and IP protection) and should be a combination of the above assumptions. Therefore, the estimation boundary of bilateral TiFI can be given as follows:

$$\textbf{upper bound}: \underset{\{search\ the\ combination\ of\ TA1,TA2,TA3\}}{\textbf{argmax}} (\textbf{TiFI}^{rs}), \quad (11)$$

$$\textbf{lower bound}: \underset{\{search\ the\ combination\ of\ TA1,TA2,TA3\}}{\textbf{argmin}} (\textbf{TiFI}^{rs}). \quad (12)$$

III. Empirical Results

A. A New Map of the US-China Trade Balance

Based on the newly defined concepts of exports, we re-estimate the trade balance between the US and China. Figure 1 depicts the bilateral trade between the US and China from 2005 to 2016 using three different measures—gross trade flows, TiVA, and TiFI—based on the OECD AMNE database, including ICIO tables that were split based on firm ownership (see Table 3) and our estimation of sectoral and bilateral FDI data (see Appendix 1). From 2005 to 2016, on average, the US exports to China in TiFI terms are 20.34% (ranging from 10.73% in 2016 to 49.43% in 2005) and 8.21% (ranging from 0.57% in 2015 to 31.84% in 2005) higher than those in TiVA and traditional gross terms. On average, China's exports to the US in TiFI terms are 1.64% (ranging from 5.13% in 2005 to 0.70% in 2016) and 16.04% (ranging from 24.21% in 2005 to 9.62% in 2016) smaller than those in TiVA and traditional gross terms.

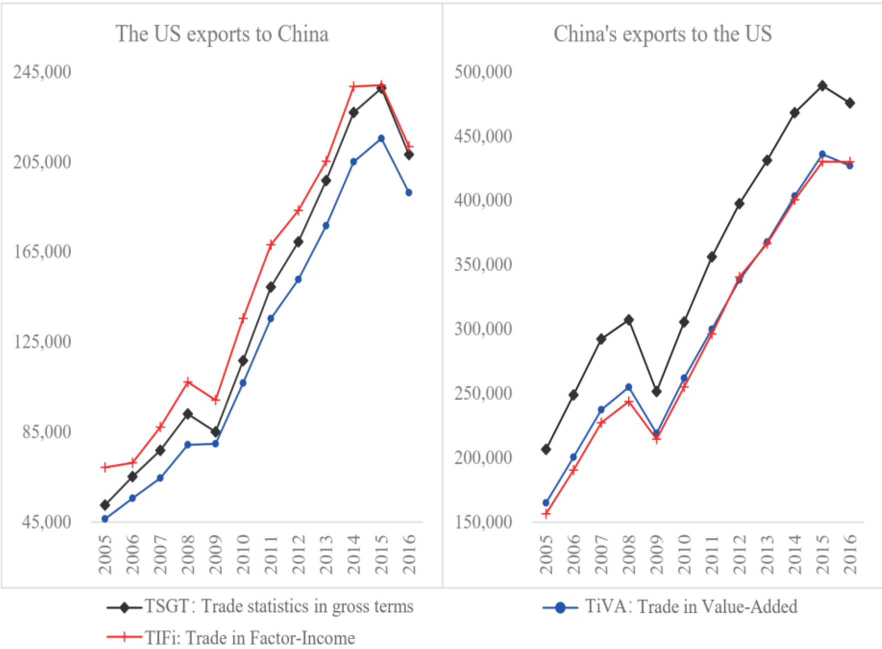


Figure 1. Bilateral trade between the US and China by different measures (Million US$)

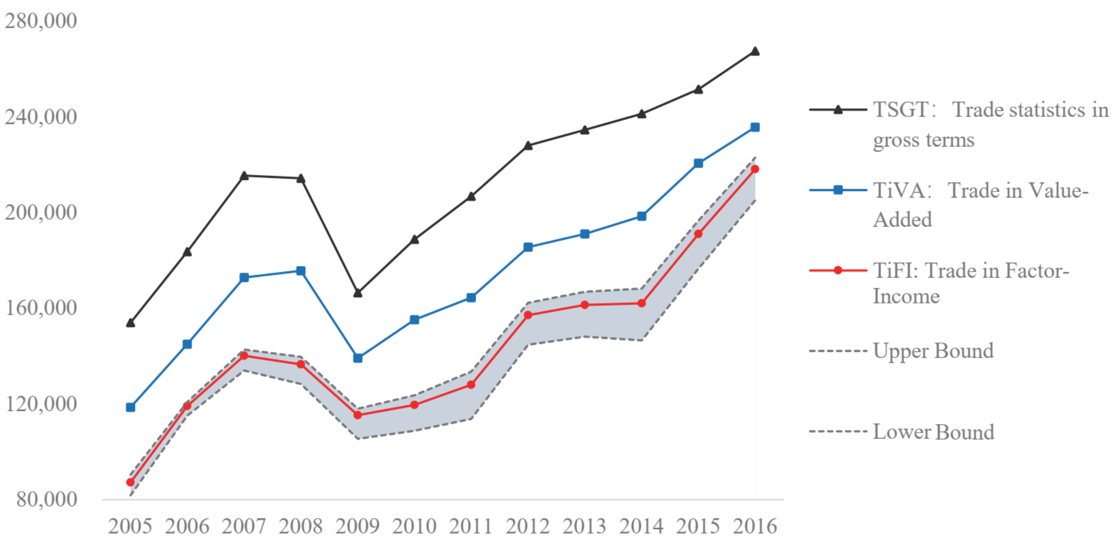
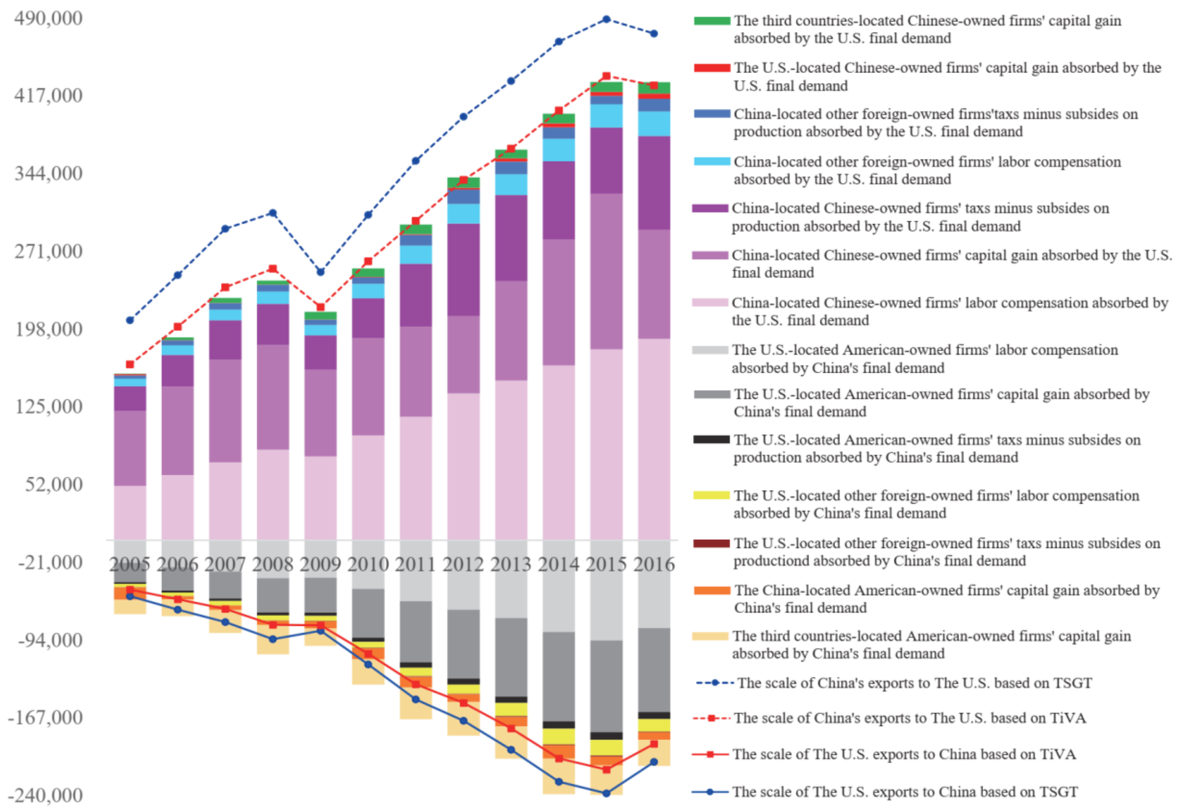


Figure 2. The China-US trade surplus by different measures (Million US$)

We also calculate the China-US trade balance using TiFI and compare it with the other two measures. Figure 2 shows that, on average, China's trade surplus with the US measured by TiFI is about 68.0% of that measured by gross trade volumes from 2005 to 2016. Compared with the trade surplus computed with TiVA, which is supposed to remove the distortion associated with foreign value-added, on average, the bilateral trade imbalance was 17.4% smaller from 2005 to 2016.



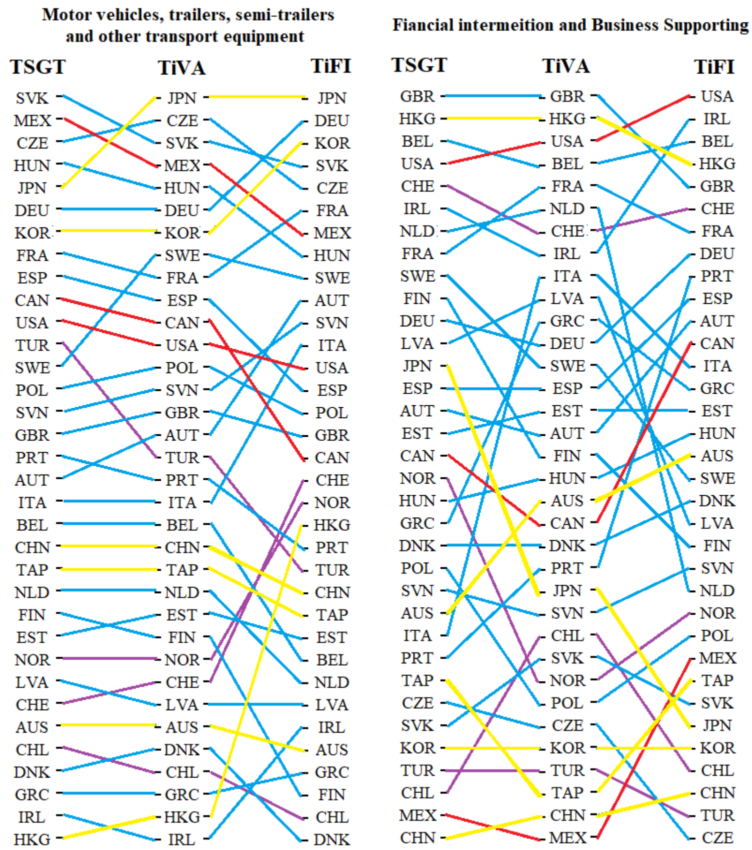
Note: TSGT: trade statistics in gross terms, TiVA: Trade in Value-Added, TiFI: Trade in Factor-Income

Note: TSGT: trade statistics in gross terms, TiVA: trade in value-added, TiFI: trade in factor income

Figure 3. The sources of the TiFI-based China-US trade surplus (Million US$)

The above phenomenon is depicted in detail in Figure 3, which shows the sources of the TiFI-based China-US trade surplus. China-based China-owned firms' value-added (return to capital, labor compensation, and net taxes on products) export to the US and the US-based the US-owned firms' value-added export to China are the main components of the China-US trade balance. These two parts also play the same role in determining the conventional TiVA-based China-US trade balance. Therefore, the main difference between TiFI and the conventional TiVA in measuring bilateral trade balance is in how the return to capital of each countries' multinationals overseas are treated. Based on our definition of TiFI, the return to capital of China-based the US-owned firms absorbed by China's final demands is treated as the US export to China, which is considered as domestic transactions in the conventional TiVA measure. The return to capital of third-country-based the US-owned firms absorbed by China's final demands is also treated as the US export to China in TiFI, which is allocated as third countries' value-added export to China in the conventional TiVA measure. Therefore, the considerable difference in the US-China trade balance using TiFI- and TiVA-based measures (Figure 2) is mainly due to the huge presence of the US-owned multinationals in the GVCs that earn more factor income from their tangible and intangible assets in overseas markets than China-owned firms (Figure 3). In addition, as shown in Figure 2, in 2016, the TiFI-based China-US trade surplus is close to the conventional TiVA-based approach, which could be explained using the information in Figure 3. The increasing return to capital of China-owned multinationals in overseas markets was induced by the US final demand and the decreasing return to capital of the US-owned multinationals in overseas markets was induced by China's final demand.

B. An Application of TiFI to Measuring Revealed Comparative Advantage



Note: TSGT: trade statistics in gross terms, TiVA: Trade in Value-Added, TiFI: Trade in Factor Income; for detailed country and sector code, see Appendices 2 and 3.

C. Figure 4. RCA based on different measures of trade

As an application of TiFI, we re-evaluate the revealed comparative advantage (RCA) based on Hoen and Oosterhaven's (2006) measure and compare it with the conventional measures in both gross and value-added terms for manufacturing sectors (using the auto industry—motor vehicles, trailers, semi-trailers, other transportation equipment—as an example) and services sectors (using financial and insurance activities as an example) in 2016 (see Figure 4). Japan, Germany, and Korea, with many big names of famous car brands, which invest all over the world to produce cars locally, ranked at the top of the RCA based on TiFI. This implies that without considering the ownership and controlling power of multinationals in measuring trade, countries such as Japan, Germany, and Korea's real comparative advantages of their tangible and intangible capital will be underestimated. Similarly, the US, Ireland, and Belgium have top RCA rankings in the financial sector according to TiFI but are underestimated by the conventional measures.

IV. Conclusion

Due to the rapid development of GVCs over the last three decades, the "made in" label, which is typical of manufactured goods (ranging from trunk planes to small electronic devices) that attribute them to a specific economy, has become an archaic symbol since most manufactured goods are now "made in the world" (WTO-IDE, 2011). According to a recent report (UNCTAD, 2013), "80% of trade takes place in 'value chains' linked to transnational corporations." Furthermore, as Cadestin et al. (2019) stated, "multinationals account roughly for one-half of international trade, one-third of output and GDP and one-fourth of employment in the global economy."

However, the exiting trade statistics highly rely on the territory-based measures (the border of the country) rather than the ownership or controlling power of firms, which may lead to a misunderstanding of a bilateral trade relationship. This study proposes a new measure, TiFI, which assigns the return to multinationals' capital to the source country of the capital owner, and we use a new model with new data, which significantly leads to a better understanding of the real size of the bilateral trade balance between countries in terms of factor income. This TiFI measure can also be considered as a type of beyond-border trade measure, which significantly improves our understanding of the nature of the complex GVCs, such as about "who produces what for whom" and "who gets factor income from where." Once returns to capital is divided into tangible and intangible parts as Alsamawi et al. (2020) did, more policy-oriented research can be done.

This TiFI measure will not only be applied in re-evaluating economic phenomenon, such as trade balance and revealed comparative advantages, but also can be used in environmental analyses, such as embodied carbon emissions, pollution, waste in international trade, and international carbon leakage, which may enrich our understanding of the so-called "pollution haven" and "race to the bottom" hypotheses as well as a better approach to sharing the responsibility of climate change in the GVCs.

Although the ultimate destination of the return to capital beyond TiFI still needs further investigation[5], this measure no doubt provides the second-best and feasible solution for a better understanding of the nature of GVCs while focusing on the owner of capital that essentially controls the firm, thereby greatly enhancing our understanding of trade from "made in" labels to "made for" or "created by" labels.

[5] For example, Fu and Ghaur (2019)' novel work to integrate trade in intangibles with detailed five modes to trade in goods and services in the context of GVCs. They found that major countries such as United States, UK, Switzerland, Japan, France, Germany and Sweden see large upward adjustments in trade imbalance. However, their work was done at the national level rather than bilateral level, without explicit consideration of inter-country production networks.

Appendix 1. The estimation of bilateral FDI flows (stocks at the sector level)

This section presents the estimation of the bilateral sectoral FDI stocks network from 2004 to 2018. High-resolution global FDI by regions and economic activities can be used to reflect global economic interconnectedness in detail. In this section, we outline the process used to construct the bilateral FDI stocks database, which involves three main steps.

Step 1. Coordinating data from different databases and mapping regions and sectors by the correspondence of ISIC.Rev.4 and ISO3.

This study employs four main databases. (1) GTAP bilateral multi-region multi-sector FDI stocks database in 2004, covering 57 sectors and 113 economics; (2) UNCTAD's bilateral FDI stocks for 206 economics (2005–2012) and the total outward FDI (OFDI) of each country to the world as the total constraint (2005-2018); (3) the Coordinated Direct Investment Survey (CDIS) released by IMF, which presents detailed data on direct investment positions from 249 to 123 economies cross-border data from 2009; (4) FDI stocks of OECD countries by industrial sector from *OECD International Direct Investment Statistics* from 2005 to 2018; (5) China's regional and sectoral OFDI stocks refer to the *Statistical Bulletin of China's OFDI*. To ensure the completeness and availability of data, we combine these different databases by sectors and regions. The industry-level bilateral FDI database we constructed includes 35 regions (including the rest of the world) and 20 sectors from 2004 to 2018, and the total number of reporting regions equals the number of partner regions.

Step 2. Adjusting the target row and column constraints and uniforming the sum constraint. Assuming that economic activities can be categorized into m sectors and n regions; $m = 20$; $n = 35$; i and j refer to reporting regions and partner regions, respectively; $i \in [1, n]$; $j \in [1, n]$; $\mathbf{M}_{j,s}^{i,t}$ represents the initial bilateral FDI stock matrix for reporting region i in year t; $x_{s,j}^{i,t}$ is the value of FDI stocks from region i to region j for sector s in year t; $t \in [0,14]$; and $s \in [1, m]$, Equation (1) indicates the structure of initial matric of the sectoral and regional FDI stocks.

$$\mathbf{M}_{j,s}^{i,t} = \begin{bmatrix} x_{1,1}^{i,t} & x_{1,2}^{i,t} & \cdots & x_{1,n-1}^{i,t} & x_{1,n}^{i,t} \\ x_{2,1}^{i,t} & x_{2,2}^{i,t} & \cdots & x_{2,n-1}^{i,t} & x_{2,n}^{i,t} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ x_{m-1,1}^{i,t} & x_{m-1,2}^{i,t} & \cdots & x_{m-1,n-1}^{i,t} & x_{m-1,n}^{i,t} \\ x_{m,1}^{i,t} & x_{m,2}^{i,t} & \cdots & x_{m,n-1}^{i,0} & x_{m,n}^{i,t} \end{bmatrix} \quad (1)$$

$$\mathbf{M}_{j}^{i,t} = \begin{bmatrix} x_{1}^{i,t} & x_{2}^{i,t} & \cdots & x_{n-1}^{i,t} & x_{n}^{i,t} \end{bmatrix} \quad (2)$$

$$\mathbf{M}_{s}^{i,t} = \begin{bmatrix} x_{1}^{i,t} & x_{2}^{i,t} & \cdots & x_{m-1}^{i,t} & x_{m}^{i,t} \end{bmatrix}', \quad (3)$$

where $\mathbf{M}_{j}^{i,t}$ and $\mathbf{M}_{s}^{i,t}$ in Equations (2) and (3) refer to the column total as the regional constraint and the row total as the sectoral constraint of the initial matrix, respectively. To ensure the convergence of the following estimated iterative procedure, it is vital to keep the sum of the column total equal to the sum of the row total. Uniformity and incommensurability cannot be ensured if the sums of different years are based on different statistical methods and sources. Equation (4) does not always work. Although the initial matrix and constraint are based on the same database (GTAP bilateral FDI stocks for the basic year), the initial data for other years are from other different databases. To solve this issue, we take the sums of 2004 to 2018 for each region from UNCTAD.

$$\sum_{j=1}^{n} \mathbf{M}_{j}^{i,t} = \sum_{s=1}^{m} \mathbf{M}_{s}^{i,t} = \mathbf{M}^{i,t} = \mathbf{T}^{i,t} \quad (4)$$

For the basic year ($t = 0$), $\mathbf{M}_{j,s}^{i,t}$ = $\mathbf{M}_{s,j}^{i,0}$, which meets the condition of $\sum_{j=1}^{n} \mathbf{M}_{j}^{i,0} = \sum_{s=1}^{m} \mathbf{M}_{s}^{i,0} = \mathbf{M}^{i,0}$, $\mathbf{M}^{i,0} \neq \mathbf{T}^{i,0}$, so we replace $\mathbf{M}^{i,0}$ with $\mathbf{T}^{i,0}$ and then redistribute the sectoral and regional distribution for each reporting region using Equations (5) to (8).

$$\mathbf{R}_{j}^{i,0} = \mathbf{M}_{j}^{i,0} / \mathbf{M}^{i,0} \quad (5)$$

$$\mathbf{R}_{s}^{i,0} = \mathbf{M}_{s}^{i,0} / \mathbf{M}^{i,0} \quad (6)$$

$$\mathbf{v}^{*i,0} = \mathbf{R}_j^{i,0} \cdot \mathbf{T}^{i,0} \tag{7}$$

$$\mathbf{u}^{*i,0} = \mathbf{R}_s^{i,0} \cdot \mathbf{T}^{i,0}, \tag{8}$$

where $\mathbf{R}_j^{i,0}$ and $\mathbf{R}_s^{i,0}$ are the regional and sectoral distribution ratios, respectively; $\boldsymbol{v}^{*i,0}$ and $\boldsymbol{u}^{*i,0}$ are the new target column and row constraints, respectively.

From 2005 to 2018 ($t = 1,2,\cdots,14$), the row and column constraints are calculated using the sectoral structure based on the OECD database; the regional structure is based on UNCTAD (2005-2008) and CDIS (2009-2018). Both are combined with the reporting regions (i), which is recorded as the total OFDI $\mathbf{T}^{i,t}$, to obtain the new column $\mathbf{v}^{*i,t}$ and the column row constraints $\mathbf{u}^{*i,t}$ by industry and reporting region based on the corresponding databases; they are given as follows:

$$\mathbf{v}^{*i,t} = \mathbf{R}_j^{*i,t} \cdot \mathbf{T}^{i,t} \tag{9}$$

$$\mathbf{u}^{*i,t} = \mathbf{R}_s^{*i,t} \cdot \mathbf{T}^{i,t}. \tag{10}$$

Step 3. RAS by regions and years based on the initial matrix and target column and row constraints. The initial matrix for the current year based on the structure of the estimated matrix $\tilde{\mathbf{M}}_{j,s}^{i,t-1}$ in year $t-1$ for each region except for the basic year. If $t = 0$, $\mathbf{M}_{j,s}^{i,0}$ is the initial matrix, otherwise it is $\tilde{\mathbf{M}}_{j,s}^{i,t-1}$.

$$\tilde{\mathbf{M}}_{j,s}^{i,t} = \begin{bmatrix} \tilde{x}_{1,1}^{i,t} & \tilde{x}_{1,2}^{i,t} & \cdots & \tilde{x}_{1,n-1}^{i,t} & \tilde{x}_{1,n}^{i,t} \\ \tilde{x}_{2,1}^{i,t} & \tilde{x}_{2,2}^{i,t} & \cdots & \tilde{x}_{2,n-1}^{i,t} & \tilde{x}_{2,n}^{i,t} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \tilde{x}_{m-1,1}^{i,t} & \tilde{x}_{m-1,2}^{i,t} & \cdots & \tilde{x}_{m-1,n-1}^{i,t} & \tilde{x}_{m-1,n}^{i,t} \\ \tilde{x}_{m,1}^{i,t} & \tilde{x}_{m,2}^{i,t} & \cdots & \tilde{x}_{m,n-1}^{i,t} & \tilde{x}_{m,n}^{i,t} \end{bmatrix} \tag{11}$$

$$\tilde{\mathbf{M}}_{j}^{i,t} = \sum_{s=1}^{m} \tilde{x}_{s,j}^{i,t} = \mathbf{u}^{i,t} \tag{12}$$

$$\tilde{\mathbf{M}}_{s}^{i,t} = \sum_{j=1}^{n} \tilde{x}_{s,j}^{i,t} = \mathbf{v}^{i,t} \tag{13}$$

The new column and row totals of the estimated matrix are represented in the vector $\mathbf{u}^{i,t}$ and $\mathbf{v}^{i,t}$; $\mathbf{s}_{l}^{i,t} = \left(\mathbf{u}^{*}\right)^{i,t} / \mathbf{u}^{i,t}$ and $\mathbf{r}_{k}^{i,t} = \left(\mathbf{v}^{*}\right)^{i,t} / \mathbf{v}^{i,t}$ are the row and column multipliers, respectively. This study applies the RAS approach, which is achieved by multiplying $\mathbf{M}_{j,s}^{i,t}$ by the diagonal matrix $\hat{\mathbf{s}}_{l}^{i,t}$ and $\hat{\mathbf{r}}_{k}^{i,t}$ until both the row and column totals converge to the target vectors. Then, the final estimated matrix will be ready to undergo a sequence of iterative multiplications as follows:

$$\tilde{\mathbf{M}}_{s,j}^{i,0} = \hat{\mathbf{s}}_{l}^{i,0}\hat{\mathbf{s}}_{l-1}^{i,0} \cdots \hat{\mathbf{s}}_{2}^{i,0}\hat{\mathbf{s}}_{1}^{i,0}\mathbf{M}_{s,j}^{i,0}\hat{\mathbf{r}}_{1}^{i,0}\hat{\mathbf{r}}_{2}^{i,0} \cdots \hat{\mathbf{r}}_{k-1}^{i,0}\hat{\mathbf{r}}_{k}^{i,0} \ (t=0) \tag{14}$$

$$\tilde{\mathbf{M}}_{s,j}^{i,t} = \hat{\mathbf{s}}_{l}^{i,t}\hat{\mathbf{s}}_{l-1}^{i,t} \cdots \hat{\mathbf{s}}_{2}^{i,t}\hat{\mathbf{s}}_{1}^{i,t}\tilde{\mathbf{M}}_{s,j}^{i,t-1}\hat{\mathbf{r}}_{1}^{i,t}\hat{\mathbf{r}}_{2}^{i,t} \cdots \hat{\mathbf{r}}_{k-1}^{i,t}\hat{\mathbf{r}}_{k}^{i,t} \quad (t \geq 1), \tag{15}$$

where $\hat{\mathbf{s}}_{1}^{i,t}\hat{\mathbf{s}}_{2}^{i,t} \cdots \hat{\mathbf{s}}_{l-1}^{i,t}\hat{\mathbf{s}}_{l}^{i,t} = \hat{\mathbf{S}}^{i,t}$ and $\hat{\mathbf{r}}_{k}^{i,t}\hat{\mathbf{r}}_{k-1}^{i,t} \cdots \hat{\mathbf{r}}_{2}^{i,t}\hat{\mathbf{r}}_{1}^{i,t} = \hat{\mathbf{R}}^{i,t}$. The rows and columns are adjusted l and k times to obtain the final FDI stocks matrix. The adjustment process from 2005 to 2018 can be modified as follows:

$$\tilde{\mathbf{M}}_{s,j}^{i,t} = \hat{\mathbf{S}}\tilde{\mathbf{M}}_{s,j}^{i,t-1}\hat{\mathbf{R}} \tag{16}$$

The estimated FDI stocks matrix by reporting regions can be integrated into one table, where, as shown in Figure A1, the columns and rows represent the reporting and partner regions of each sector, respectively.

Reporting regions (Column) /Partner regions (Row)		P_1	…	P_n
S_1	R_1	$\widetilde{M}^{i,t}_{1,j}$		
	…			
	R_n			
…	…	…		
S_m	R_1	$\widetilde{M}^{i,t}_{20,j}$		
	…			
	R_n			

Note: S_m *represents sectors* m *;* R_n *and* P_n *refer to the reporting regions* n *and partner regions* n*, respectively.*

Figure A1. The structure of bilateral sectoral FDI

Appendix 2. More applications of TiFI

TiFI not only works for the US-China trade relation but can also be systematically and consistently applied to every bilateral relation in GVCs. Figure A2 depicts how bilateral trade relations are different across these three measures. Although the conventional TiVA-based bilateral trade balance corrects the traditional gross trade statistics-based approach by solving the double counting problem, they are highly correlated, so the overall view on the global unbalance does not change significantly. This is mainly because both ignore the "hidden trade" problem, which was mentioned in the previous section. By contrast, a relatively lower correlation could be found between TiFI and either the traditional gross trade statistics or the conventional TiVA in measuring bilateral trade balance.

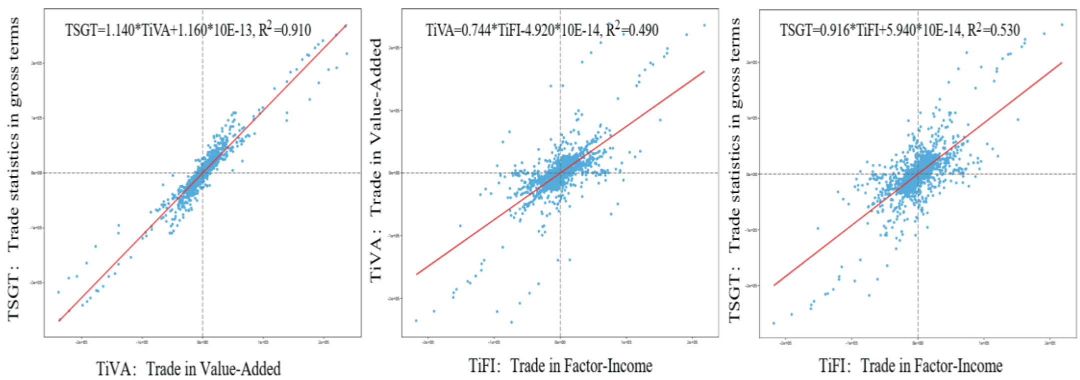


Figure A2. Correlations among three measures of bilateral trade balance (2005-2016)

To show how the TiFI-based measure differs from others, and how it can significantly improve our understanding of bilateral trade balances, we pick some country pairs that have a relatively large amount of bilateral trade balance and illustrate their relationships in 2016 in Figure A3. The circle size of each country or region in the figure shows the absolute magnitude of trade volume (the sum of the absolute value of export and import according to different terms, such as gross term, value-added term, and factor income term). The thickness and arrow show the magnitude and direction of net exports in different measures, respectively.

There is no significant structural difference but just a little difference in the magnitude of bilateral trade balance between the traditional gross trade statistics-based measure and the conventional TiVA-based measure. Ranking by magnitude, the US had a huge trade deficit with China, EU21, Mexico, Canada, and Japan but had a trade surplus with Australia. China had a huge trade surplus with the US, EU21, and Mexico but had a trade deficit with Chinese Taipei, Korea, Australia, and Hong Kong. However, the TiFI-based net trade flow for some countries shows different magnitudes from the conventional TiVA-based measure. For example, the China-US and EU21-US trade surplus declined, whereas the Japan-US and Korea-US trade surplus increased. The US-Australia trade surplus appeared more outstandingly; the Mexico-US, Australia-China, Turkey-Canada, and Australia-Japan trade surplus declined greatly (using the same threshold as that of convention TiVA); the EU21-Mexico and Hong Kong-China trade surplus is outstandingly obvious. All these differences between the conventional TiVA and TiFI approaches reflect the importance of considering the ownership of factor income in understanding bilateral trade balances.

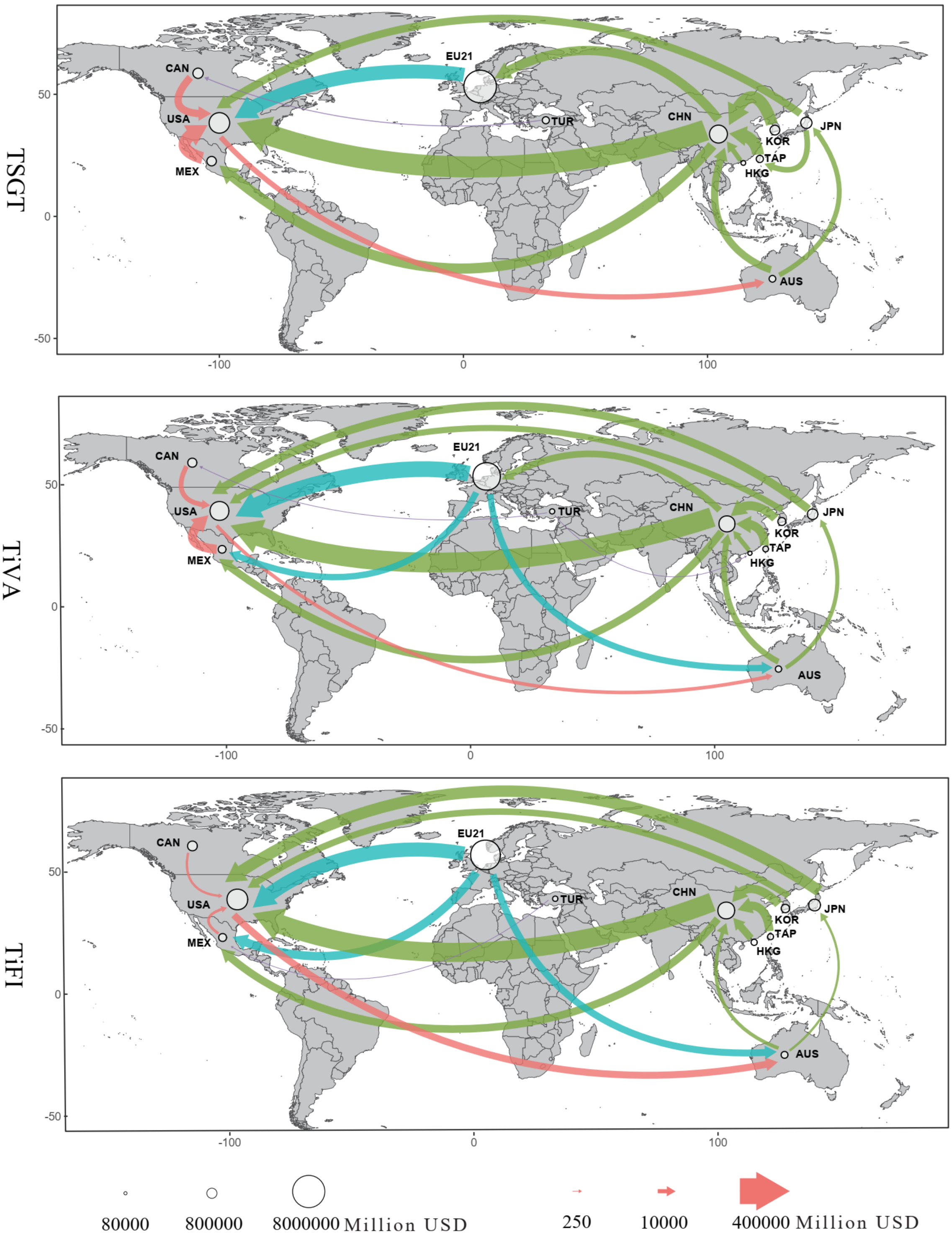


Figure A3. Bilateral trade balance by different measures（2016）

Appendix 3. Country/region code in the OECD, Analytical AMNE Database

OECD code	OECD countries	Non-OECD code	Non-OECD economies
AUS 1	Australia	ARG 37	Argentina
AUT 2	Austria	BRA 38	Brazil
BEL 3	Belgium	BGR 39	Bulgaria
CAN 4	Canada	CHN 40	China (People's Republic of)
CHL 5	Chile	COL 41	Colombia
CZE 6	Czech Republic	CRI 42	Costa Rica
DNK 7	Denmark	HRV 43	Croatia
EST 8	Estonia	CYP 44	Cyprus[6]
FIN 9	Finland	IND 45	India
FRA 10	France	IDN 46	Indonesia
DEU 11	Germany	HKG 47	Hong Kong, China
GRC 12	Greece	MYS 48	Malaysia
HUN 13	Hungary	MLT 49	Malta
ISL 14	Iceland	MAR 50	Morocco
IRL 15	Ireland	PHL 51	Philippines
ISR 16	Israel[7]	ROU 52	Romania
ITA 17	Italy	RUS 53	Russian Federation
JPN 18	Japan	SAU 54	Saudi Arabia
KOR 19	Korea	SGP 55	Singapore
LVA 20	Latvia	ZAF 56	South Africa
LTU 21	Lithuania	TWN 57	Chinese Taipei
LUX 22	Luxembourg	THA 58	Thailand
MEX 23	Mexico	VNM 59	Viet Nam
NLD 24	Netherlands	ROW 60	Rest of the World
NZL 25	New Zealand		
NOR 26	Norway		
POL 27	Poland		
PRT 28	Portugal		
SVK 29	Slovak Republic		
SVN 30	Slovenia		
ESP 31	Spain		
SWE 32	Sweden		
CHE 33	Switzerland		
TUR 34	Turkey		
GBR 35	United Kingdom		
USA 36	United States		

Source: ReadMe_analytical AMNE.xlsx from the OECD (https://www.oecd.org/sti/ind/amne.htm)

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[6] Footnote on Turkey: The information in this document about "Cyprus" relates to the southern part of the island. There is no single authority representing both Turkish and Greek Cypriot people on the island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position in the "Cyprus issue." Footnote on all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognized by all members of the United Nations, except Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

[7] The statistical data on Israel are supplied by and under the responsibility of the relevant Israeli authorities or third party. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem, and Israeli settlements in the West Bank under the terms of international law.

Appendix 4. Industry (sector) code of the OECD AMNE ICIO data

Code 1	Code 2	Industry
A	1	Agriculture, forestry, and fishing
B	2	Mining and extraction of energy-producing products
C10T12	3	Food products, beverages, and tobacco
C13T15	4	Textiles, wearing apparel, leather, and related products
C16	5	Wood and products of wood and cork
C17T18	6	Paper products and printing
C19	7	Coke and refined petroleum products
C20T21	8	Chemicals and pharmaceutical products
C22	9	Rubber and plastic products
C23	10	Other non-metallic mineral products
C24	11	Basic metals
C25	12	Fabricated metal products
C26	13	Computer, electronic, and optical products
C27	14	Electrical equipment
C28	15	Machinery and equipment, nec.
C29	16	Motor vehicles, trailers, and semi-trailers
C30	17	Other transport equipment
C31T33	18	Other manufacturing (repair and installation of machinery and equipment)
DTE	19	Electricity, gas, water supply, sewerage, waste, and remediation services
F	20	Construction
G	21	Wholesale and retail trade (repair of motor vehicles)
H	22	Transportation and storage
I	23	Accommodation and food services
J58T60	24	Publishing, audiovisual, and broadcasting activities
J61	25	Telecommunications
J62T63	26	IT and other information services
K	27	Financial and insurance activities
L	28	Real estate activities
MTN	29	Other business sector services
O	30	Public administration and defense (compulsory social security)
P	31	Education
Q	32	Human health and social work
RTS	33	Arts, entertainment, recreation, and other service activities
T	34	Private households with employed persons

Source: ReadMe_analytical AMNE.xlsx from the OECD (https://www.oecd.org/sti/ind/amne.htm)

Reference

Xing, Y., & H. Detert. How the iPhone Widens the United States Trade Deficit with the People's Republic of China. *ADBI Working Paper* **257**, 1-8 (2010).

Johnson, R. & G. Noguera. Accounting for Intermediates: Production Sharing and Trade in Value-added. *Journal of International Economics* **86 (2)**, 224-236 (2012).

Koopman, R., Wang, Z. & S.-J. Wei. Tracing Value-added and Double Counting in Gross Exports. *American Economic Review* **104 (2)**, 459-494 (2014).

WTO. *Global Value Chain Development Report 2017: Measuring and Analyzing the Impact of GVCs on Economic Development*, WTO (2017).

Zhang, Z., Xiong, Y. & X. Ji. *The US-China Trade War Is Based on Misleading Statistics.* http://voxchina.org/show-3-90.html (2018).

IMF. People's Republic of China: Staff Report for the 2020 Article IV Consultation. *IMF Country Report* **21 (6)**, January 2021 (2021).

The Reuters. *Why Intangible Assets Matter.* https://www.reuters.com/article/sponsored/why-intangible-assets-matter (2020).

WTO. *General Agreement on Tariffs and Trade 1994 ("GATT 1994").* https://www.wto.org/english/docs_e/legal_e/06-gatt_e.htm (1994).

de Haan, M. & J. Haynes. R&D Capitalisation: Where Did We Go Wrong? NBER Chapters, in: The Challenges of Globalization in the Measurement of National Accounts, *National Bureau of Economic Research*, Inc (2018).

Brothers, J. From the Double Irish to the Bermuda Triangle. *Tax Analysts,* 687-695 (2014).

Xing, Y. Global Value Chains and the "missing exports" of the United States. *China Economic Review* **61**,101429 (2020).

Baldwin, R., Ito, T. & H. Sato. The Smile Curve: Evolving Sources of Value-Added in

Manufacturing. *Joint Research Program Series*, IDE-JETRO (2014).

Setser, B. W. Apple's Exports Aren't Missing: They Are in Ireland. *Council on Foreign Relations* (2017).

Garcia-Bernardo, J., Fichtner, J., Takes, F. W., & E. M. Heemskerk. Uncovering Offshore Financial Centers: Conduits and Sinks in the Global Corporate Ownership Network. *Scientific Reports* **7 (1)**, 1-11 (2017).

Cadestin, C., Backer, K. Desnoyers-James, I., Miroudot, S., Rigo, D. & M. Ye. Multinational Enterprises and Global Value Chains: The OECD Analytical AMNE Database. *OECD Trade Policy Papers* **211**, February 2018 (2018).

WTO-IDE. *Trade Patterns and Global Value Chains in East Asia: From Trade to Goods to Trade in Tasks, printed by the WTO Secretariat* (2011).

UNCTAD. World Investment Report 2013 Global Value Chains: Investment and Trade for Development. *United Nations Conference on Trade and Development, United Nations Publication* (2013).

Cadestin, C., Backer, K., Miroudot, S., Moussiegt, L., Rigo, D. & M. Ye. Multinational Enterprises in Domestic Value Chains. *OECD Science, Technology and Industry Policy Papers* **63** (2019).

Alsamawi, A., Cadestin, C., Jaax, A., Guilhoto, J., Miroudot, S. and C. Zurcher. Returns to intangible capital in global value chains: New evidence on trends and policy determinants. *OECD Publishing, Paris, OECD Trade Policy Papers* **240** (2020).

Leontief, W. W. Quantitative Input and Output Relations in the Economic Systems of the United States. *The Review of Economics and Statistics* **18**, 105-125 (1936).

Hoen, A. R. & J. Oosterhaven. On the measurement of comparative advantage. *The Annals of Regional Science* **40**, 677-691 (2006).

Fu, X. & P. Ghauri. Trade in intangibles and the global trade imbalance. *The World Economy* **44 (5)**, 1448-1469 (2021).

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