Estimating Ownership-Based Bilateral Trade and Its Contribution to World GDP

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Abstract: This paper attempts to estimate ownership-based bilateral trade and its contribution to world GDP by using the OECD Activity of Multinational Enterprises (AMNE) Database. The novelty includes: i) The "OECD Inter-Country Input-Output table split according to ownership" in the AMNE database distinguishes domestic-owned and foreign-owned firms. We further spilt the foreign-owned firms in these tables according to their parent economies. This provides basic data for estimating ownership-based bilateral trade; ii) We propose a systematic approach to estimating ownership-based bilateral trade by using the "inter-country input-output tables split according to ownership of parent economies"; iii) We evaluate the contribution of ownership-based bilateral trade to world GDP by using inter-country input-output model with hypothetical extraction method and give implications on the potential impact of ownership-based trade protection policies.

Keywords: Ownership-Based Trade, Hypothetical Extraction Method, Inter-Country Input-Output Model

1.Introduction

Bilateral trade balance is one of the issues that has garnered significant attention from academia and government. Large trade deficit is often used as a motivation for trade protection policies. However, in the context of the development of foreign direct investment and the expansion of global value chains, economies around the world have been closely interdependent through the establishment of a commercial presence. This has had a subversive impact on the traditional international trade statistics that measure the gains from international trade.

On the one hand, the sales by subsidiaries established in Economy B through direct investment from Economy A to the local sectors in Economy B are essentially extensions of exports from Economy A to Economy B (Wang et al., 2021). These sales largely reflect the gains of Economy A. However, the traditional international trade statistics based on the "rule of residence" do not include these transactions as exports from Economy A to Economy B. On the other hand, a significant portion of

the exports from Economy B to Economy A are completed by foreign-owned enterprises. However, the ownership of these exports belongs to the foreign enterprises and does not represent the gains of Economy B (Ekholm et al., 2007; Tintelnot, 2017). In addition, to avoid the trade protection in Economy A, Economy B could establish affiliates in Economy C for production and further export to Economy A.

Considering the substitutive effect of foreign direct investment on traditional trade, the traditional "rule of residence" for identifying bilateral trade no longer accurately reflects the actual trade benefits of both parties (Jia, 2006). Academia has been attempting to re-estimate the bilateral trade from the perspective of ownership. Ownership-based trade is identified based on whether the transfer of commodity (service) ownership changes "nationality", rather than whether the commodity (service) is cross-border or not(Zhou and Zhu, 2024). Therefore, ownership-based trade can be achieved not only through cross-border transactions between resident and non-resident units, but also by establishing a business presence abroad.

This paper attempts to estimate ownership-based bilateral trade and its contribution to world GDP by using the OECD Activity of Multinational Enterprises (AMNE) Database (Cadestin et al., 2018). The novelty includes: i) The "OECD Inter-Country Input-Output table split according to ownership" in the AMNE database distinguishes domestic-owned and foreign-owned firms. We further spilt the foreign-owned firms in these tables according to their parent economies. This provides basic data for estimating ownership-based bilateral trade; ii) We propose a systematic approach to estimating ownership-based bilateral trade by using the "inter-country input-output tables split according to ownership of parent economies"; iii) We evaluate the contribution of ownership-based bilateral trade to world GDP by using inter-country input-output model with hypothetical extraction method and give implications on the potential impact of ownership-based trade protection policies.

The preliminary study finds that horizontal FDI and export platform FDI play a significant role in substituting traditional residence-based trade. Some economies export a large amount of goods and services to its trading partners by establishing affiliates through investments in third economies. For instance, the third-economy platforms for U.S. exports to China are mainly distributed in the Asia-Pacific region, including Singapore, Australia, Japan, Malaysia, and South Korea. The gap between China and the United States in terms of FDI has substantially reduced the trade balance between the two sides. The traditional residence-based trade balance seriously distorts trade benefits. Formulating trade policies based on residence-based trade statistics will lead to biases and may even trigger unnecessary trade friction.

2. Ownership-Based Inter-Country Input-Output Tables

Inter-country input-output tables that distinguish between domestic and foreign-owned sectors provide detailed data on intermediate goods transactions and final demand across economies. These tables encompass comprehensive trade statistics, including both goods and services, and constitute an essential data foundation for constructing ownership-based inter-country input-output tables and analyzing ownership-attributed trade flows.

2.1 Description of Basic Data

Table 1 presents an input-output framework consisting of 3 economies and n industries, where in each industry in each economy is classified by ownership into domestic-owned(d) and foreign-owned(f) sectors.

Table 1. Inter-country Input-Output Table with Domestic and foreign-owned sectors

			Intermediate Use						Final Use			Total Output
			Economy r		Economy s		Economy t		r	s	t	
			d	f	d	f	d	f	y	y	y	
			$1...n$	$1...n$	$1...n$	$1...n$	$1...n$	$1...n$				
Economy r	d	$1 \dots n$	$\boldsymbol{Z}_{rd}^{rd}$	$\boldsymbol{Z}_{rd}^{rf}$	$\boldsymbol{Z}_{rd}^{sd}$	$\boldsymbol{Z}_{rd}^{sf}$	$\boldsymbol{Z}_{rd}^{td}$	$\boldsymbol{Z}_{rd}^{tf}$	$\boldsymbol{y}_{rd}^{r}$	$\boldsymbol{y}_{rd}^{s}$	$\boldsymbol{y}_{rd}^{t}$	$\boldsymbol{x}_{rd}$
	f	$1 \dots n$	$\boldsymbol{Z}_{rf}^{rd}$	$\boldsymbol{Z}_{rf}^{rf}$	$\boldsymbol{Z}_{rf}^{sd}$	$\boldsymbol{Z}_{rf}^{sf}$	$\boldsymbol{Z}_{rf}^{td}$	$\boldsymbol{Z}_{rf}^{tf}$	$\boldsymbol{y}_{rf}^{r}$	$\boldsymbol{y}_{rf}^{s}$	$\boldsymbol{y}_{rf}^{t}$	$\boldsymbol{x}_{rf}$
Economy s	d	$1 \dots n$	$\boldsymbol{Z}_{sd}^{rd}$	$\boldsymbol{Z}_{sd}^{rf}$	$\boldsymbol{Z}_{sd}^{sd}$	$\boldsymbol{Z}_{sd}^{sf}$	$\boldsymbol{Z}_{sd}^{td}$	$\boldsymbol{Z}_{sd}^{tf}$	$\boldsymbol{y}_{sd}^{r}$	$\boldsymbol{y}_{sd}^{s}$	$\boldsymbol{y}_{sd}^{t}$	$\boldsymbol{x}_{sd}$
	f	$1 \dots n$	$\boldsymbol{Z}_{sf}^{rd}$	$\boldsymbol{Z}_{sf}^{rf}$	$\boldsymbol{Z}_{sf}^{sd}$	$\boldsymbol{Z}_{sf}^{sf}$	$\boldsymbol{Z}_{sf}^{td}$	$\boldsymbol{Z}_{sf}^{tf}$	$\boldsymbol{y}_{sf}^{r}$	$\boldsymbol{y}_{sf}^{s}$	$\boldsymbol{y}_{sf}^{t}$	$\boldsymbol{x}_{sf}$
Economy t	d	$1 \dots n$	$\boldsymbol{Z}_{td}^{rd}$	$\boldsymbol{Z}_{td}^{rf}$	$\boldsymbol{Z}_{td}^{sd}$	$\boldsymbol{Z}_{td}^{sf}$	$\boldsymbol{Z}_{td}^{td}$	$\boldsymbol{Z}_{td}^{tf}$	$\boldsymbol{y}_{td}^{r}$	$\boldsymbol{y}_{td}^{s}$	$\boldsymbol{y}_{td}^{t}$	$\boldsymbol{x}_{td}$
	f	$1 \dots n$	$\boldsymbol{Z}_{tf}^{rd}$	$\boldsymbol{Z}_{tf}^{rf}$	$\boldsymbol{Z}_{tf}^{sd}$	$\boldsymbol{Z}_{tf}^{sf}$	$\boldsymbol{Z}_{tf}^{td}$	$\boldsymbol{Z}_{tf}^{tf}$	$\boldsymbol{y}_{tf}^{r}$	$\boldsymbol{y}_{tf}^{s}$	$\boldsymbol{y}_{tf}^{t}$	$\boldsymbol{x}_{tf}$
Value Added			$\boldsymbol{v}_{rd}^{'}$	$\boldsymbol{v}_{rf}^{'}$	$\boldsymbol{v}_{sd}^{'}$	$\boldsymbol{v}_{sf}^{'}$	$\boldsymbol{v}_{td}^{'}$	$\boldsymbol{v}_{tf}^{'}$				
Total Input			$\boldsymbol{x}_{rd}^{'}$	$\boldsymbol{x}_{rf}^{'}$	$\boldsymbol{x}_{sd}^{'}$	$\boldsymbol{x}_{sf}^{'}$	$\boldsymbol{x}_{td}^{'}$	$\boldsymbol{x}_{tf}^{'}$				

In Table 1, superscripts indicate the user of the product, and subscripts indicate

the provider. For example, the matrix $\boldsymbol{Z}_{rd}^{rf}$ (of dimension $n \times n$) represents the intermediate input of products from economy r's domestic-owned sectors consumed in the production of economy r's foreign-owned sectors. The vector $\boldsymbol{y}_{rd}^{s}$ (of dimension $n \times 1$) represents final the demand of economy s for products produced by r's domestic-owned sectors. The total output (or input) of these sectors is indicated as $\boldsymbol{x}_{rd}$, and their corresponding value-added is represented by $\boldsymbol{v}_{rd}^{'}$.

Ownership-based inter-country input-output tables are still compiled primarily according to the territorial principle. The foreign-owned sectors are not further disaggregated by ownership economy, requiring additional ownership disaggregation of foreign-owned sectors using host economy data on total output by investment source economy.

Bilateral output flow tables provide information on the distribution of industrial outputs in each host economy, broken down by source economy. Table 2 presents such an inter-country bilateral output flow table, comprising 3 economies and n industries.

Table 2. Inter-Country Bilateral Output Flow Table

		Economy r	Economy s	Economy t
Economy r	1 ... n	$\boldsymbol{op}_r^r$	$\boldsymbol{op}_s^r$	$\boldsymbol{op}_t^r$
Economy s	1 ... n	$\boldsymbol{op}_r^s$	$\boldsymbol{op}_s^s$	$\boldsymbol{op}_t^s$
Economy t	1 ... n	$\boldsymbol{op}_r^t$	$\boldsymbol{op}_s^t$	$\boldsymbol{op}_t^t$

In Table 2, superscripts indicate the user(consuming economy), and subscripts indicate the provider(producing economy). For example, the element $\boldsymbol{op}_s^r$ (of dimension $n \times 1$) indicates the intermediate use of products from economy s by industries in economy r.

2.2. Disaggregation Process Description

2.2.1. Disaggregation of Intermediate Flow Matrix(Z)

In Table 1, the column vector $\boldsymbol{Z}^{rf} = \left(\boldsymbol{Z}_{rd}^{rf} \quad \boldsymbol{Z}_{rf}^{rf} \quad \boldsymbol{Z}_{sd}^{rf} \quad \boldsymbol{Z}_{sf}^{rf} \quad \boldsymbol{Z}_{td}^{rf} \quad \boldsymbol{Z}_{tf}^{rf}\right)^{'}$ represents the intermediate inputs into economy r's n foreign-owned industries, of dimension $6n \times n$. To identify contributions from economy s and t, this vector $\boldsymbol{Z^{rf}}$ is decomposed based on the proportional structure of bilateral output flows.

According to the bilateral output matrix, the proportion of output in the i-th($i \in$

$(1\cdots n))$ sector of economy r coming from economy s or economy t is given by:

$$\boldsymbol{P}_s^r = \frac{\boldsymbol{op}_s^r}{\boldsymbol{op}_s^r+\boldsymbol{op}_t^r}, \boldsymbol{P}_t^r = \frac{\boldsymbol{op}_t^r}{\boldsymbol{op}_s^r+\boldsymbol{op}_t^r} \quad (1)$$

Let $\boldsymbol{P^r} = \begin{pmatrix} \frac{\boldsymbol{op}_s^r}{\boldsymbol{op}_s^r+\boldsymbol{op}_t^r} \\ \frac{\boldsymbol{op}_t^r}{\boldsymbol{op}_s^r+\boldsymbol{op}_t^r} \end{pmatrix}'$, of dimension $n \times 2$

Using the fixed proportion assumption, we assume the proportions of inputs from s and t economies in the i-th industry of $\boldsymbol{Z}^{rf}$ are consistent with $\boldsymbol{P^r}$ in the bilateral output matrix. Multiplying the i-th column of $\boldsymbol{Z}^{rf}$ by the i-th row of $\boldsymbol{P^r}$ yields $\dot{\boldsymbol{Z}}^{rf}$ (of dimension $6n \times 2n$), representing the portions of intermediate inputs from s and t economies in r's foreign-owned industries. Similarly, extending $\boldsymbol{Z^{sf}}$ and $\boldsymbol{Z^{tf}}$, the matrix $\boldsymbol{Z}$ is extended to $\dot{\boldsymbol{Z}}$(of dimension $6n \times 9n$).

Based on $\dot{\boldsymbol{Z}}$, further row extension is conducted.

$\dot{\boldsymbol{Z}}_{rf} = \begin{pmatrix} \boldsymbol{Z}_{rf}^{rd} \\ \dot{\boldsymbol{Z}}_{rf}^{rf} \\ \boldsymbol{Z}_{rf}^{sd} \\ \dot{Z}_{rf}^{sf} \\ \boldsymbol{Z}_{rf}^{td} \\ \dot{Z}_{rf}^{tf} \end{pmatrix}'$ represents the intermediate output row vector for r's foreign-owned industries. Assuming the distribution of outputs to economies s and t in $\dot{\boldsymbol{Z}}_{\boldsymbol{rf}}$ follows the same proportions as the bilateral output matrix $\boldsymbol{P^r}$, transposing the i-th row of $\boldsymbol{P^r}$ and multiplying it by the i-th row of $\dot{\boldsymbol{Z}}_{\boldsymbol{rf}}$(of dimension $n \times 9n$) yields $\ddot{\boldsymbol{Z}}_{\boldsymbol{rf}}$, representing the portions of intermediate goods from r's foreign-owned industries flowing to s and t economies. Similarly extending $\dot{\boldsymbol{Z}}_{\boldsymbol{sf}}$ and $\dot{\boldsymbol{Z}}_{\boldsymbol{tf}}$, the matrix $\dot{\boldsymbol{Z}}$ is extended to $\ddot{\boldsymbol{Z}}$(of dimension $9n \times 9n$).

2.2.2. Disaggregation of Final Demand Matrix($\boldsymbol{y}$)

Taking economy r's final demand column vector $\boldsymbol{y^r} = \begin{pmatrix} \boldsymbol{y_{rd}^r} & \boldsymbol{y_{rf}^r} & \boldsymbol{y_{sd}^r} & \boldsymbol{y_{sf}^r} & \boldsymbol{y_{td}^r} & \boldsymbol{y_{tf}^r} \end{pmatrix}'$ as an example. Since $\boldsymbol{y^r}$ only differentiates domestic and foreign-owned sectors row-wise, extension is only needed row-wise. Under the fixed proportion assumption, assuming the proportions of inputs from s and t economies in $\boldsymbol{y_{rf}^r}$ are consistent with $\boldsymbol{P^r}$, transposing the i-th row of $\boldsymbol{P^r}$ and multiplying it by the i-th row of $\boldsymbol{y_{rf}^r}$(of dimension $n \times 1$) yields $\ddot{\boldsymbol{y}}_{\boldsymbol{rf}}^{\boldsymbol{r}}$, representing r's final demand for industries in s and t economies. Similarly extending $\boldsymbol{y_{sf}^r}$ and

$\boldsymbol{y_{tf}^{r}}$, the vector $\boldsymbol{y^{r}}$ is extended to $\ddot{\boldsymbol{y}}^{\boldsymbol{r}}$(of dimension $9n \times 1$).

The same approach applies to extending $\boldsymbol{y^{s}}$ and $\boldsymbol{y^{t}}$.

2.2.3. Extension of Value Added Row Vector($\boldsymbol{v}'$)

From Table 1, the value added row vector is: $\boldsymbol{v}' = \begin{pmatrix} \boldsymbol{v}'_{rd} & \boldsymbol{v}'_{rf} & \boldsymbol{v}'_{sd} & \boldsymbol{v}'_{sf} & \boldsymbol{v}'_{td} & \boldsymbol{v}'_{tf} \end{pmatrix}$, Since $\boldsymbol{v}'$ only differentiates domestic and foreign-owned sectors column-wise, extension is only needed column-wise. Assuming the proportions of inputs from s and t economies in $\boldsymbol{v}'_{rf}$ are consistent with $\boldsymbol{P^{r}}$, multiplying the i-th column of $\boldsymbol{v}'_{rf}$ by the i-th row of $\boldsymbol{P^{r}}$ yields $\ddot{\boldsymbol{v}}_{rf}$ (of dimension $6n \times 2n$), representing the portions of value added from s and t economies in r's foreign-owned industries. Similarly extending $\boldsymbol{v}'_{sf}$ and $\boldsymbol{v}'_{tf}$, the vector $\boldsymbol{v}'$ is extended to $\ddot{\boldsymbol{v}}'$(of dimension $1 \times 9n$).

2.2.4. Extension of Total Output Column Vector($\boldsymbol{x}$)

Since the bilateral output matrix $\boldsymbol{op^{r}} = \begin{pmatrix} \boldsymbol{op_{r}^{r}} \\ \boldsymbol{op_{s}^{r}} \\ \boldsymbol{op_{t}^{r}} \end{pmatrix}'$ explicitly provides the shares of domestic and foreign sources within each industry of economy r, replacing the foreign portions in $\boldsymbol{x_{rf}}$ with those from s and t economies extends $\boldsymbol{x_{rf}}$(dimension $n \times 1$) to $\ddot{\boldsymbol{x}}_{\boldsymbol{rf}}$(dimension $2n \times 1$). Similarly extending $\boldsymbol{x_{sf}}$ and $\boldsymbol{x_{tf}}$, the vector $\boldsymbol{x}$ is extended to:$\ddot{\boldsymbol{x}} = (\boldsymbol{x_{rd}} \quad \ddot{\boldsymbol{x}}_{\boldsymbol{rf}} \quad \boldsymbol{x_{sd}} \quad \ddot{\boldsymbol{x}}_{\boldsymbol{sf}} \quad \boldsymbol{x_{td}} \quad \ddot{\boldsymbol{x}}_{\boldsymbol{tf}})'$(of dimension $9n \times 1$).

The final Ownership-based inter-country input-output table is presented in Table 3.

Table 3. Ownership-Based Inter-Country Input-Output Table

				Intermediate Use									Final Use			Total Output
				Economy r			Economy s			Economy t			Economy r	Economy s	Economy t	
				d	f		d	f		d	f					
					Economy s	Economy t		Economy r	Economy t		Economy r	Economy s				
				$1...n$	$1...n$	$1...n$	$1...n$	$1...n$	$1...n$	$1...n$	$1...n$	$1...n$				
Economy r		d	$1 \dots n$	$\boldsymbol{Z}_{rd}^{rd}$	$\boldsymbol{Z}_{rd}^{rf^s}$	$\boldsymbol{Z}_{rd}^{rf^t}$	$\boldsymbol{Z}_{rd}^{sd}$	$\boldsymbol{Z}_{rd}^{sf^r}$	$\boldsymbol{Z}_{rd}^{sf^t}$	$\boldsymbol{Z}_{rd}^{td}$	$\boldsymbol{Z}_{rd}^{tf^r}$	$\boldsymbol{Z}_{rd}^{tf^s}$	$\boldsymbol{y}_{rd}^{r}$	$\boldsymbol{y}_{rd}^{s}$	$\boldsymbol{y}_{rd}^{t}$	$\boldsymbol{x}_{rd}$
	f	Economy s	$1 \dots n$	$\boldsymbol{Z}_{rf^s}^{rd}$	$\boldsymbol{Z}_{rf^s}^{rf^s}$	$\boldsymbol{Z}_{rf^s}^{rf^t}$	$\boldsymbol{Z}_{rf^s}^{sd}$	$\boldsymbol{Z}_{rf^s}^{sf^r}$	$\boldsymbol{Z}_{rf^s}^{sf^t}$	$\boldsymbol{Z}_{rf^s}^{td}$	$\boldsymbol{Z}_{rf^s}^{tf^r}$	$\boldsymbol{Z}_{rf^s}^{tf^s}$	$\boldsymbol{y}_{rf^s}^{r}$	$\boldsymbol{y}_{rf^s}^{s}$	$\boldsymbol{y}_{rf^s}^{t}$	$\boldsymbol{x}_{rf^s}$
		Economy t	$1 \dots n$	$\boldsymbol{Z}_{rf^t}^{rd}$	$\boldsymbol{Z}_{rf^t}^{rf^s}$	$\boldsymbol{Z}_{rf^t}^{rf^t}$	$\boldsymbol{Z}_{rf^t}^{sd}$	$\boldsymbol{Z}_{rf^t}^{sf^r}$	$\boldsymbol{Z}_{rf^t}^{sf^t}$	$\boldsymbol{Z}_{rf^t}^{td}$	$\boldsymbol{Z}_{rf^t}^{tf^r}$	$\boldsymbol{Z}_{rf^t}^{tf^s}$	$\boldsymbol{y}_{rf^t}^{r}$	$\boldsymbol{y}_{rf^t}^{s}$	$\boldsymbol{y}_{rf^t}^{t}$	$\boldsymbol{x}_{rf^t}$
Economy s		d	$1 \dots n$	$\boldsymbol{Z}_{sd}^{rd}$	$\boldsymbol{Z}_{sd}^{rf^s}$	$\boldsymbol{Z}_{sd}^{rf^t}$	$\boldsymbol{Z}_{sd}^{sd}$	$\boldsymbol{Z}_{sd}^{sf^r}$	$\boldsymbol{Z}_{sd}^{sf^t}$	$\boldsymbol{Z}_{sd}^{td}$	$\boldsymbol{Z}_{sd}^{tf^r}$	$\boldsymbol{Z}_{sd}^{tf^s}$	$\boldsymbol{y}_{sd}^{r}$	$\boldsymbol{y}_{sd}^{s}$	$\boldsymbol{y}_{sd}^{t}$	$\boldsymbol{x}_{sd}$
	f	Economy r	$1 \dots n$	$\boldsymbol{Z}_{sf^r}^{rd}$	$\boldsymbol{Z}_{sf^r}^{rf^s}$	$\boldsymbol{Z}_{sf^r}^{rf^t}$	$\boldsymbol{Z}_{sf^r}^{sd}$	$\boldsymbol{Z}_{sf^r}^{sf^r}$	$\boldsymbol{Z}_{sf^r}^{sf^t}$	$\boldsymbol{Z}_{sf^r}^{td}$	$\boldsymbol{Z}_{sf^r}^{tf^r}$	$\boldsymbol{Z}_{sf^r}^{tf^s}$	$\boldsymbol{y}_{sf^r}^{r}$	$\boldsymbol{y}_{sf^r}^{s}$	$\boldsymbol{y}_{sf^r}^{t}$	$\boldsymbol{x}_{sf^r}$
		Economy t	$1 \dots n$	$\boldsymbol{Z}_{sf^t}^{rd}$	$\boldsymbol{Z}_{sf^t}^{rf^s}$	$\boldsymbol{Z}_{sf^t}^{rf^t}$	$\boldsymbol{Z}_{sf^t}^{sd}$	$\boldsymbol{Z}_{sf^t}^{sf^r}$	$\boldsymbol{Z}_{sf^t}^{sf^t}$	$\boldsymbol{Z}_{sf^t}^{td}$	$\boldsymbol{Z}_{sf^t}^{tf^r}$	$\boldsymbol{Z}_{sf^t}^{tf^s}$	$\boldsymbol{y}_{sf^t}^{r}$	$\boldsymbol{y}_{sf^t}^{s}$	$\boldsymbol{y}_{sf^t}^{t}$	$\boldsymbol{x}_{sf^t}$
Economy t		d	$1 \dots n$	$\boldsymbol{Z}_{td}^{rd}$	$\boldsymbol{Z}_{td}^{rf^s}$	$\boldsymbol{Z}_{td}^{rf^t}$	$\boldsymbol{Z}_{td}^{sd}$	$\boldsymbol{Z}_{td}^{sf^r}$	$\boldsymbol{Z}_{td}^{sf^t}$	$\boldsymbol{Z}_{td}^{td}$	$\boldsymbol{Z}_{td}^{tf^r}$	$\boldsymbol{Z}_{td}^{tf^s}$	$\boldsymbol{y}_{td}^{r}$	$\boldsymbol{y}_{td}^{s}$	$\boldsymbol{y}_{td}^{t}$	$\boldsymbol{x}_{td}$
	f	Economy r	$1 \dots n$	$\boldsymbol{Z}_{tf^r}^{rd}$	$\boldsymbol{Z}_{tf^r}^{rf^s}$	$\boldsymbol{Z}_{tf^r}^{rf^t}$	$\boldsymbol{Z}_{tf^r}^{sd}$	$\boldsymbol{Z}_{tf^r}^{sf^r}$	$\boldsymbol{Z}_{tf^r}^{sf^t}$	$\boldsymbol{Z}_{tf^r}^{td}$	$\boldsymbol{Z}_{tf^r}^{tf^r}$	$\boldsymbol{Z}_{tf^r}^{tf^s}$	$\boldsymbol{y}_{tf^r}^{r}$	$\boldsymbol{y}_{tf^r}^{s}$	$\boldsymbol{y}_{tf^r}^{t}$	$\boldsymbol{x}_{tf^r}$
		Economy s	$1 \dots n$	$\boldsymbol{Z}_{tf^s}^{rd}$	$\boldsymbol{Z}_{tf^s}^{rf^s}$	$\boldsymbol{Z}_{tf^s}^{rf^t}$	$\boldsymbol{Z}_{tf^s}^{sd}$	$\boldsymbol{Z}_{tf^s}^{sf^r}$	$\boldsymbol{Z}_{tf^s}^{sf^t}$	$\boldsymbol{Z}_{tf^s}^{td}$	$\boldsymbol{Z}_{tf^s}^{tf^r}$	$\boldsymbol{Z}_{tf^s}^{tf^s}$	$\boldsymbol{y}_{tf^s}^{r}$	$\boldsymbol{y}_{tf^s}^{s}$	$\boldsymbol{y}_{tf^s}^{t}$	$\boldsymbol{x}_{tf^s}$
Value Added				$\boldsymbol{v}_{rd}^{'}$	$\boldsymbol{v}_{rf^s}^{'}$	$\boldsymbol{v}_{rf^t}^{'}$	$\boldsymbol{v}_{sd}^{'}$	$\boldsymbol{v}_{sf^r}^{'}$	$\boldsymbol{v}_{sf^t}^{'}$	$\boldsymbol{v}_{td}^{'}$	$\boldsymbol{v}_{tf^r}^{'}$	$\boldsymbol{v}_{tf^s}^{'}$				
Total Input				$\boldsymbol{x}_{rd}^{'}$	$\boldsymbol{x}_{rf^s}^{'}$	$\boldsymbol{x}_{rf^t}^{'}$	$\boldsymbol{x}_{sd}^{'}$	$\boldsymbol{x}_{sf^r}^{'}$	$\boldsymbol{x}_{sf^t}^{'}$	$\boldsymbol{x}_{td}^{'}$	$\boldsymbol{x}_{tf^r}^{'}$	$\boldsymbol{x}_{tf^s}^{'}$				

In Table 3, superscripts indicate the user of the product, and subscripts indicate the provider. For example, the matrix $\boldsymbol{Z}_{rd}^{rfs}$ (of dimension $n \times n$) represents the quantity of products from the domestic industries of economy r used by the s-owned sectors in economy r during production. The vector $\boldsymbol{y}_{rf^s}^{r}$ (of dimension $n \times 1$) represents the demand from economy r for final goods produced by the s-owned industrial sectors in economy r. $\boldsymbol{x}_{rf^s}^{'}$ represents the total output (input) of the s-owned industrial sectors in economy r, and $\boldsymbol{v}_{rf^s}^{'}$ indicates the value added of the s-owned industrial sectors in economy r.

3. Estimation of Ownership-Based Trade

3.1 Data Sources and Processing

This paper primarily utilizes the Analytical AMNE Database published by the OECD, which provides inter-country input-output tables distinguishing domestic-owned and foreign-owned sectors, as well as host economy output data by source economy of investment (inter-country bilateral output flow tables). These data adopt the same economy classification (76 economies and ROW, Rest of the World), industry classification (41 industries), and time span (2008-2020).

Extending the Ownership-based inter-country input-output tables to ownership-based tables according to the 77-economy classification in the AMNE database would face high computational pressure. Therefore, based on the 2023 global FDI net outflows published by the World Bank, this paper selects the top 25 economies by FDI net outflow (the United States, Japan, China, Hong Kong China, Germany, Canada, the United Kingdom, Singapore, Sweden, Spain, France, South Korea, Italy, Brazil, Switzerland, Saudi Arabia, Poland, India, Thailand, Australia, Denmark, Russia, Norway, Israel, Austria). Combining with the actual FDI amounts utilized by China from various economies published by the National Bureau of Statistics of China in 2023, it is found that the actual FDI amounts from the Netherlands and Taiwan China are also at relatively high levels. Meanwhile, calculations based on the Ownership-based input-output table data in the AMNE database show that the sum of output from foreign-owned sectors of these 27 economies accounts for over 75% of the global total output from foreign-owned sectors, indicating that the foreign-owned sectors of these 27 economies can represent the production and trade activities of the vast majority of foreign-owned sectors worldwide. Therefore, in subsequent disaggregation and analysis, these 27 economies are retained as key economies, while the remaining economies are consolidated.

3.2 Methodology for Ownership-Based Trade Estimation

This paper uses Ownership-based inter-country input-output tables to estimate ownership-based trade. The bilateral trade matrix in this table is a harmonized trade

matrix, satisfying that the exports from Economy *A* to Economy *B* are exactly the imports from Economy *B* to Economy *A*, and the trade balance estimated with Economy *A* as the reporting economy is completely consistent with that estimated with Economy *B* as the reporting economy(Chen and Jia, 2023). Therefore, only the ownership-based export volumes of each economy need to be estimated to obtain the bilateral ownership-based trade flow matrix between economies.

Taking the estimation of ownership-based exports from economy r to economy s as an example, it can be further divided into ownership-based exports of intermediate goods and final goods. The estimation methods for these two types of ownership-based exports are introduced separately.

3.2.1 Estimation of Ownership-Based Exports of Intermediate Goods

The ownership-based exports of intermediate goods from economy r to economy s are further divided into the following four categories. Here, TZ represents ownership-based exports of intermediate goods, with subscripts denoting the exporter and superscripts denoting the importer; uppercase letters indicate the host economy, and lowercase letters indicate the ownership economy.

1) Intermediate goods export volume from sectors owned by r in host economy r to sectors owned by s in host economy $s(TZ_{Rr}^{Ss})$

According to Table 3, the intermediate goods export volume TZ_{Rr}^{Ss} from sectors owned by r in host economy r to sectors owned by s in host economy s can be estimated by the intermediate goods exports $\boldsymbol{Z}_{rd}^{sd}$ from domestic-owned sectors of r to domestic-owned sectors of s. The estimation formula for TZ_{Rr}^{Ss} is as follows ($\boldsymbol{i}$ is a summation column vector with all elements equal to 1)

$$T_{Rr}^{Ss} = \boldsymbol{i}'\boldsymbol{Z}_{rd}^{sd}\boldsymbol{i} \tag{3}$$

2) Intermediate goods export volume from sectors owned by r in host economy r to sectors owned by s in other host economies$(TZ_{Rr}^{Rs} + TZ_{Rr}^{Ts})$

The intermediate goods export volume from sectors owned by r in host economy r to sectors owned by s in other host economies consists of two parts: first, the intermediate goods export volume TZ_{Rr}^{Rs} from domestic-owned sectors of r to sectors owned by s in host economy r can be estimated by $\boldsymbol{Z}_{rd}^{rf^s}$; second, the intermediate goods export volume TZ_{Rr}^{Ts} from domestic-owned sectors of r to sectors owned by s in host economy t can be estimated by $\boldsymbol{Z}_{rd}^{tf^s}$. The estimation formula for $T_{Rr}^{Rs} + T_{Rr}^{Ts}$ is as follows:

$$T_{Rr}^{Rs} + T_{Rr}^{Ts} = \boldsymbol{i}'\boldsymbol{Z}_{rd}^{rf^s}\boldsymbol{i} + \boldsymbol{i}'\boldsymbol{Z}_{rd}^{tf^s}\boldsymbol{i} \tag{4}$$

3) Intermediate goods export volume from sectors owned by r in other host economies to sectors owned by s in host economy $s(TZ_{Sr}^{Ss} + TZ_{Tr}^{Ss})$

The intermediate goods export volume from sectors owned by r in other host economies to sectors owned by s in host economy s consists of two parts: first, the

intermediate goods export volume TZ_{Sr}^{Ss} from sectors owned by r in host economy s to domestic-owned sectors of s can be estimated by $\boldsymbol{Z}_{sf^r}^{sd}$; second, the intermediate goods export volume TZ_{Tr}^{Ss} from sectors owned by r in host economy t to domestic-owned sectors of s can be estimated by $\boldsymbol{Z}_{tf^r}^{sd}$. The estimation formula for $T_{Sr}^{Ss} + T_{Tr}^{Ss}$ is as follows:

$$T_{Sr}^{Ss} + T_{Tr}^{Ss} = \boldsymbol{i}'\boldsymbol{Z}_{sf^r}^{sd}\boldsymbol{i} + \boldsymbol{i}'\boldsymbol{Z}_{tf^r}^{sd}\boldsymbol{i} \quad (5)$$

4) Intermediate goods export volume from sectors owned b r in other host economies to sectors owned by s in other host economies($TZ_{Sr}^{Rs} + TZ_{Sr}^{Ts} + TZ_{Tr}^{Rs} + TZ_{Tr}^{Ts}$)

The intermediate goods export volume from sectors owned by r in other host economies to sectors owned by s in other host economies consists of four parts: first, TZ_{Sr}^{Rs} can be estimated by $\boldsymbol{Z}_{sf^r}^{rf^s}$; second, TZ_{Sr}^{Ts} can be estimated by $\boldsymbol{Z}_{sf^r}^{tf^s}$; third, TZ_{Tr}^{Rs} can be estimated by $\boldsymbol{Z}_{tf^r}^{rf^s}$; fourth, TZ_{Tr}^{Ts} can be estimated by $\boldsymbol{Z}_{tf^r}^{tf^s}$. The estimation formula for $TZ_{Sr}^{Rs} + TZ_{Sr}^{Ts} + TZ_{Tr}^{Rs} + TZ_{Tr}^{Ts}$ is as follows:The intermediate goods export volume from sectors owned by r in other host economies to sectors owned by s in other host economies consists of four parts: first, TZ_{Sr}^{Rs} can be estimated by $\boldsymbol{Z}_{sf^r}^{rf^s}$; second, TZ_{Sr}^{Ts} can be estimated by $\boldsymbol{Z}_{sf^r}^{tf^s}$; third, TZ_{Tr}^{Rs} can be estimated by $\boldsymbol{Z}_{tf^r}^{rf^s}$; fourth, TZ_{Tr}^{Ts} can be estimated by $\boldsymbol{Z}_{tf^r}^{tf^s}$. The estimation formula for $TZ_{Sr}^{Rs} + TZ_{Sr}^{Ts} + TZ_{Tr}^{Rs} + TZ_{Tr}^{Ts}$ is as follows:

$$TZ_{Sr}^{Rs} + TZ_{Sr}^{Ts} + TZ_{Tr}^{Rs} + TZ_{Tr}^{Ts} = \boldsymbol{i}'\boldsymbol{Z}_{sf^r}^{rf^s}\boldsymbol{i} + \boldsymbol{i}'\boldsymbol{Z}_{sf^r}^{tf^s}\boldsymbol{i} + \boldsymbol{i}'\boldsymbol{Z}_{tf^r}^{rf^s}\boldsymbol{i} + \boldsymbol{i}'\boldsymbol{Z}_{tf^r}^{tf^s}\boldsymbol{i} \quad (6)$$

3.2.1 Estimation of Ownership-Based Exports of Final Goods

The ownership-based exports of final goods from economy r to economy s are further divided into the following two categories. Here, TY represents ownership-based exports of final goods, with subscripts denoting the exporter and superscripts denoting the importer; uppercase letters indicate the host economy, and lowercase letters indicate the ownership economy.

1) Final goods export volume from sectors owned by r in host economy r to economy s(TY_{Rr}^{s})

According to Table 3, the final goods export volume TY_{Rr}^{s} from sectors owned by r in host economy r to economy s can be estimated by the final goods exports $\boldsymbol{y}_{rd}^{s}$ from domestic-owned sectors of r to s. The estimation formula for TY_{Rr}^{s} is as follows:

$$TY_{Rr}^{s} = \boldsymbol{i}'\boldsymbol{y}_{rd}^{s} \quad (7)$$

2) Final goods export volume from sectors owned by r in other host economies

to economy $s(TY_{Sr}^{s} + TY_{Tr}^{s})$

The final goods export volume from sectors owned by r in other host economies to economy s consists of two parts: first, TY_{Sr}^{s} can be estimated by $\boldsymbol{y}_{sf^r}^{s}$; second, TY_{Tr}^{s} can be estimated by $\boldsymbol{y}_{tf^r}^{s}$. The estimation formula for $TY_{Sr}^{s} + TY_{Tr}^{s}$ is as follows:

$$TY_{Sr}^{s} + TY_{Tr}^{s} = \boldsymbol{i}'\boldsymbol{y}_{sf^r}^{s} + \boldsymbol{i}'\boldsymbol{y}_{tf^r}^{s} \quad (8)$$

In fact, the above estimation method for ownership-based exports of final goods still has room for improvement. In the OECD-AMNE input-output tables, final demand is further divided into final consumption by households and governments, and total investment by households, governments, and corporate sectors. Accounting for final consumption and government household investment is consistent under both ownership and territorial principles, while investment by corporate sectors should be further disaggregated under the ownership principle. Taking ownership-based exports of final goods from r to s as an example, they include not only final consumption exports and government household investment exports from r's domestic-owned sectors and affiliates to s's domestic-owned sectors, but also investment exports to s's domestic enterprises, as well as investment exports from r's domestic-owned sectors and affiliates to s-owned enterprises in other host economies. This part of the accounting involves multiple extensions of the final demand column vectors of each economy, which will be refined in future work.

3.3 Results of Ownership-Based Trade Estimation

Based on the above ownership-based trade estimation method and the 2020 inter-country input-output tables published by OECD-AMNE, the following estimation results of ownership-based trade flows among 12 key economies are obtained.

Table 4 shows the row-wise representation of export destinations and column-wise representation of import sources, with diagonal elements indicating zero trade volumes within the same economy. Taking the first row as an example, it represents Australia's ownership-based exports to 27 key economies, including exports from Australia's domestic-owned sectors to domestic-owned sectors of other economies and their affiliates in other host economies, as well as exports from Australia's affiliates in other host economies to domestic-owned sectors of other economies and their affiliates in other host economies. Taking the first column as an example, it represents Australia's ownership-based imports from 27 key economies, including imports by Australia's domestic-owned sectors from domestic-owned sectors of other economies and their affiliates in other host economies, as well as imports by Australia's affiliates in other host economies from domestic-owned sectors of other economies and their affiliates in other host economies.

As shown in Table 4, as China's largest trading partner, China's ownership-based exports to the United States reached 680.66 billion dollars in 2020, far exceeding its exports to other economies. The United States' ownership-based exports to China amounted to 548.33 billion dollars, resulting in an ownership-based trade surplus of 132.33 billion dollars for China. In 2020, Japan became China's second-largest ownership-based trading partner, with China's ownership-based exports to Japan reaching 440.85 billion dollars. Notably, Japan's ownership-based exports to China were 480.82 billion, resulting in an ownership-based trade balance of -39.97 billion dollars between the two economies. As China's third-largest ownership-based export destination, the ownership-based trade deficit with South Korea reached -140.79 billion dollars.

Table 4. Ownership-Based Trade Flow Matrix of 12 Economies in 2020

(100 million dollars)

	CAN	CHN	DEU	ESP	GBR	HKG	JPN	KOR	NLD	SGP	SWE	USA
CAN	0.0	392.8	362.8	62.0	337.9	57.1	358.6	104.4	25.3	48.1	59.5	5215.5
CHN	677.8	0.0	2324.4	335.3	1018.1	646.7	4408.5	3927.7	142.1	1049.9	322.4	6806.6
DEU	523.4	2650.5	0.0	906.7	2096.9	152.1	1153.4	538.5	42.4	173.4	692.1	6634.8
ESP	63.9	178.9	649.2	0.0	450.9	12.0	120.6	35.7	4.1	22.8	56.2	971.8
GBR	401.0	714.8	1836.4	444.6	0.0	173.3	524.3	164.2	83.9	167.2	220.7	4511.2
HKG	63.8	479.8	91.3	11.7	69.9	0.0	142.2	59.2	24.1	29.7	23.3	386.8
JPN	539.3	4808.2	1163.1	210.7	709.7	332.6	0.0	961.0	64.3	312.1	118.4	7522.2
KOR	172.2	5335.6	476.0	49.7	158.3	89.7	922.1	0.0	45.2	160.3	44.9	1990.2
NLD	16.6	173.5	18.5	2.7	56.6	16.1	46.6	26.3	0.0	17.1	2.7	153.8
SGP	58.0	1476.0	187.3	23.9	153.6	74.5	346.7	156.7	38.3	0.0	17.8	832.7
SWE	61.7	329.7	664.7	70.8	241.2	19.5	147.3	58.4	6.3	18.3	0.0	747.9
USA	4802.7	5483.3	5288.2	958.7	4881.4	579.9	5733.2	1661.6	181.5	780.8	678.3	0.0

To compare the differences in trade flows between ownership and territorial accounting principles, this paper also estimates the territorial trade of 12 key economies using the inter-country input-output tables from the OECD-AMNE database.

Combining the accounting results in Tables 4 and 5, it can be seen that for the vast majority of economies, ownership-based trade flows are larger than territorial trade flows. The main reason lies in the significant difference in the statistical scope of exports under the ownership principle and the territorial principle. Territorial trade is based on the "territorial principle", which counts exports from enterprise sectors in Economy A to enterprise sectors in Economy B according to whether goods and services cross borders; ownership-based trade is based on the "ownership principle", which counts exports from enterprise sectors owned by Economy A to enterprise sectors owned by Economy B according to whether the ownership of goods and

services crosses national boundaries. The rapid growth of FDI has created a situation where economies are “An interconnected pattern where each contains elements of the other”, and the trade of overseas affiliates between the two economies should be fully considered to reflect the true trade gains of each economy from the perspective of ownership-based trade.

Table 5. Territorial Trade Flow Matrix of 12 Economies in 2020

(100 million dollars)

	CAN	CHN	DEU	ESP	GBR	HKG	JPN	KOR	NLD	SGP	SWE	USA
CAN	0.0	248.5	71.1	15.3	106.6	6.9	116.9	62.4	6.5	19.4	11.5	2776.6
CHN	653.7	0.0	1075.9	329.9	736.2	488.6	1922.6	1301.8	87.8	327.6	103.7	4277.7
DEU	143.7	1103.3	0.0	375.1	673.6	23.5	266.1	217.5	18.6	82.3	218.9	1173.8
ESP	29.9	134.5	325.5	0.0	227.4	1.8	32.0	21.0	4.7	11.5	34.3	209.9
GBR	89.4	309.3	482.2	147.3	0.0	47.4	149.1	78.8	10.9	120.8	100.2	991.6
HKG	16.2	273.4	29.4	2.1	48.1	0.0	31.5	26.0	2.0	61.8	3.6	129.3
JPN	129.0	1775.1	212.4	33.7	125.6	104.1	0.0	412.7	21.1	252.8	18.0	1192.9
KOR	101.6	1786.9	101.2	24.8	58.4	42.5	308.1	0.0	20.2	88.0	9.8	779.7
NLD	6.9	104.8	7.8	1.9	12.0	1.2	22.3	13.3	0.0	7.6	0.8	53.2
SGP	34.6	604.5	120.0	6.1	65.8	85.0	265.0	140.4	23.8	0.0	4.4	405.0
SWE	21.4	137.0	164.2	34.9	87.3	1.8	45.3	19.5	2.8	8.7	0.0	158.2
USA	2266.8	1715.3	813.5	192.0	708.0	87.7	1120.0	643.2	47.4	365.4	123.0	0.0

Under the territorial principle, the United States remains China’s largest export destination. Comparing the ownership-based and territorial trade flows between China and the United States, China’s territorial exports to the U.S. amounted to 427.77 billion dollars in 2020, 37.1% lower than its ownership-based exports. U.S. territorial exports to China were only 171.53 billion dollars, 68.7% lower than its ownership-based exports. The territorial trade surplus between China and the U.S. was 256.24 billion dollars, 93.7% higher than the ownership-based trade surplus. Estimating China-U.S. trade flows under the territorial principle while ignoring ownership-based trade conducted through third economies leads to a serious overestimation of the ownership-based trade balance between the two nations.

Comparing the ownership-based and territorial trade flows between China and its second- and third-largest export destinations, Japan and South Korea, it is found that in 2020, there was a territorial trade surplus of 14.75 billion dollars between China and Japan, significantly different from the ownership-based trade deficit of -39.97 billion dollars. The territorial trade deficit between China and South Korea was -48.51 billion dollars, 65.5% lower than the ownership-based trade deficit.

By subtracting the territorial trade flow matrix from the ownership-based trade flow matrix of the 12 economies, the ownership-territorial trade balance flow matrix shown in Table 6 is further obtained.

Table 6. Ownership-Territorial Trade Balance Flow Matrix of 12 Economies in 2020

(100 million dollars)

	CAN	CHN	DEU	ESP	GBR	HKG	JPN	KOR	NLD	SGP	SWE	USA
CAN	0.0	144.3	291.8	46.7	231.3	50.2	241.8	42.0	18.8	28.6	48.0	2438.8
CHN	24.1	0.0	1248.5	5.4	281.9	158.1	2485.9	2625.9	54.2	722.4	218.7	2528.9
DEU	379.7	1547.3	0.0	531.6	1423.4	128.5	887.3	320.9	23.8	91.1	473.2	5460.9
ESP	34.0	44.5	323.7	0.0	223.4	10.2	88.7	14.6	-0.6	11.4	21.9	761.9
GBR	311.6	405.5	1354.3	297.3	0.0	125.9	375.2	85.3	73.0	46.5	120.5	3519.6
HKG	47.6	206.4	61.8	9.7	21.8	0.0	110.7	33.2	22.0	-32.0	19.7	257.6
JPN	410.3	3033.0	950.7	177.0	584.1	228.5	0.0	548.3	43.2	59.3	100.3	6329.3
KOR	70.6	3548.7	374.8	24.9	99.9	47.2	613.9	0.0	25.0	72.3	35.1	1210.5
NLD	9.7	68.7	10.7	0.7	44.6	14.9	24.3	13.1	0.0	9.6	1.9	100.6
SGP	23.4	871.4	67.2	17.8	87.8	-10.5	81.7	16.4	14.6	0.0	13.5	427.7
SWE	40.3	192.7	500.5	35.9	153.9	17.7	102.0	38.9	3.5	9.6	0.0	589.6
USA	2535.9	3768.0	4474.6	766.7	4173.3	492.2	4613.3	1018.4	134.1	415.4	555.3	0.0

As shown in Table 6, the total ownership-territorial export balance flow of the United States reached 22947.2 billion dollars, which is closely related to the U.S. ranking first globally in FDI net outflows. Exporting through overseas affiliates is an important way for the U.S. to benefit from international trade. Japan, the world's second-largest economy in FDI net outflows, had a total ownership-territorial export balance flow of 12463.9 billion dollars. China and Germany, which rank closely behind in global FDI net outflows, both had ownership-territorial export balance totals exceeding 10000 billion dollars, placing them at high global levels. The correlation between the total ownership-territorial export balance flows and economies' FDI net outflows further verifies that ownership-based trade accounting, which takes into account trade between economies' overseas affiliates, is a useful complement to the trade accounting framework in the context of rapid FDI development.

With weak global economic recovery, rising unilateralism and protectionism, and ongoing geopolitical conflicts, global value chains are accelerating their restructuring toward localization and regionalization (Lv Yue et al., 2024). Taking China and the U.S. as an example, in recent years, the U.S. has successively developed "nearshoring" with Mexico and "friendshoring" with Vietnam and India, leading Chinese enterprises to increase investments in economies such as Mexico to carry out trade activities with the U.S. by leveraging low tariff advantages. However, the U.S. may further strictly formulate ownership regulations for imported goods in the future, requiring strict national ownership restrictions on intermediate and final goods directly exported to the U.S. Therefore, it is necessary to study the potential impacts of trade disruptions and various ownership-based trade protection policies on national economies and even the global economy from an ownership perspective.

4. Potential Impacts of Ownership-Based Trade Disruptions

4.1 Introduction to the Measurement Model

The Hypothetical Extraction Method (HEM) was initially proposed by Paelinck, de Caevel, and Degueldre (1965) and Strassert (1968). This method "extracts" trade relations between certain economies from the input-output relations of the actual world economy, that is, sets trade flows between specific economies to zero, forming a hypothetical economic structure. By comparing changes in the global economy before and after the "extraction", it evaluates the potential impacts of various ownership-based trade disruptions on the world economy.

Taking the disruption of global ownership-based trade as an example, the inter-country intermediate use matrix and final use matrix in this scenario are as follows:

$$\boldsymbol{Z^0}=\begin{bmatrix} \boldsymbol{Z}_{rd}^{rd} & 0 & 0 & 0 & \boldsymbol{Z}_{rd}^{sf^r} & 0 & 0 & \boldsymbol{Z}_{rd}^{tf^r} & 0 \\ 0 & \boldsymbol{Z}_{rf^s}^{rf^s} & 0 & \boldsymbol{Z}_{rf^t}^{rf^t} & 0 & 0 & 0 & 0 & \boldsymbol{Z}_{rf^s}^{tf^s} \\ 0 & 0 & \boldsymbol{Z}_{rf^t}^{rf^t} & 0 & 0 & \boldsymbol{Z}_{rf^t}^{sf^t} & \boldsymbol{Z}_{rf^t}^{td} & 0 & 0 \\ 0 & \boldsymbol{Z}_{sd}^{rf^s} & 0 & \boldsymbol{Z}_{sd}^{sd} & 0 & 0 & 0 & 0 & \boldsymbol{Z}_{sd}^{tf^s} \\ \boldsymbol{Z}_{sf^r}^{rd} & 0 & 0 & 0 & \boldsymbol{Z}_{sf^r}^{sf^r} & 0 & 0 & \boldsymbol{Z}_{sf^r}^{tf^r} & 0 \\ 0 & 0 & \boldsymbol{Z}_{sf^t}^{rf^t} & 0 & 0 & \boldsymbol{Z}_{sf^t}^{sf^t} & \boldsymbol{Z}_{sf^t}^{td} & 0 & 0 \\ 0 & 0 & \boldsymbol{Z}_{td}^{rf^t} & 0 & 0 & \boldsymbol{Z}_{td}^{sf^t} & \boldsymbol{Z}_{td}^{td} & 0 & 0 \\ \boldsymbol{Z}_{tf^r}^{rd} & 0 & 0 & 0 & \boldsymbol{Z}_{tf^r}^{sf^r} & 0 & 0 & \boldsymbol{Z}_{tf^r}^{tf^r} & 0 \\ 0 & \boldsymbol{Z}_{tf^s}^{rf^s} & 0 & \boldsymbol{Z}_{tf^s}^{sd} & 0 & 0 & 0 & 0 & \boldsymbol{Z}_{tf^s}^{tf^s} \end{bmatrix},\ \boldsymbol{y}^0=\begin{bmatrix} \boldsymbol{y}_{rd}^{r} & 0 & 0 \\ 0 & \boldsymbol{y}_{rf^s}^{s} & 0 \\ 0 & 0 & \boldsymbol{y}_{rf^t}^{t} \\ 0 & \boldsymbol{y}_{sd}^{s} & 0 \\ \boldsymbol{y}_{sf^r}^{r} & 0 & 0 \\ 0 & 0 & \boldsymbol{y}_{sf^t}^{t} \\ 0 & 0 & \boldsymbol{y}_{td}^{t} \\ \boldsymbol{y}_{tf^r}^{r} & 0 & 0 \\ 0 & \boldsymbol{y}_{tf^s}^{s} & 0 \end{bmatrix}$$

In the input-output framework, GDP^1 can be calculated based on Table:

$$GDP^1=\boldsymbol{w}'\boldsymbol{L}(\boldsymbol{y}^r+\boldsymbol{y}^s+\boldsymbol{y}^t) \tag{9}$$

Where $\boldsymbol{w}'=\boldsymbol{v}'(\boldsymbol{x})^{-1}$ is the row vector of value-added ratios, $\boldsymbol{L}=(\boldsymbol{I}-\boldsymbol{A})^{-1}$ is the Leontief inverse matrix of the global production system, $\boldsymbol{I}$ is the identity matrix, and $\boldsymbol{A}=\boldsymbol{Z}(\widehat{\boldsymbol{x}})^{-1}$ is the direct input coefficient matrix of the global production system.

According to Table 7, GDP^0 under the disruption of global ownership-based trade can be calculated:

$$GDP^0=\boldsymbol{w}'\boldsymbol{L^0}(\boldsymbol{y}^{r0}+\boldsymbol{y}^{s0}+\boldsymbol{y}^{t0}) \tag{10}$$

$\boldsymbol{L^0}$、$\boldsymbol{y}^{r0}$、$\boldsymbol{y}^{s0}$、$\boldsymbol{y}^{t0}$ are the Leontief inverse matrix and final demand matrices of the global production system when global ownership-based trade is disrupted, respectively.

The impact of disrupting global ownership-based trade on GDP can be expressed as:

$$\Delta GDP=GDP^1-GDP^0 \tag{11}$$

The magnitude of ΔGDP represents the strength of the impact of disrupting global ownership-based trade on GDP.

4.2 Analysis of Measurement Results

Table 8 shows the changes in GDP of 12 major economies, the rest of the world, and the global total before and after the complete disruption of ownership-based trade.

Table 8. GDP of Each Economy Before and After Disruption of Global Ownership-Based Trade in 2020

(trillion dollars)

	GDP		
	Before Disruption of Ownership-Based Trade	After Disruption of Ownership-Based Trade	Difference Before and After Disruption
CAN	1.58	1.03	-0.55
CHN	13.92	10.96	-2.96
DEU	3.98	2.39	-1.59
ESP	1.13	0.77	-0.36
GBR	2.51	1.67	-0.84
HKG	0.28	0.18	-0.11
JPN	5.31	4.10	-1.21
KOR	1.74	1.08	-0.67
NLD	0.19	0.13	-0.06
SGP	0.34	0.11	-0.23
SWE	0.51	0.30	-0.21
USA	20.89	17.47	-3.42
ROW	29.67	20.29	-9.38
Global	82.05	60.49	-21.56

As shown in the measurement results of Table 8, disrupting ownership-based trade caused a decline in both global GDP and the GDP of individual economies, having a negative impact on economic development. In 2020, with normal global trade, the total global GDP reached 82.05 trillion dollars; if global ownership-based trade were completely disrupted, global GDP would fall to 60.49 trillion dollars, a decrease of 26.28% compared to normal trade. Ricardo's theory of comparative advantage states that economies specialize in producing goods with comparative advantages through trade and obtain other goods through exchange to maximize global output. Disrupting global ownership-based trade would break the virtuous cycle of global economic growth and trigger a series of chain crises.

At the level of individual economies, the impact of disrupting ownership-based trade on GDP is closely related to economies' FDI net outflows and actual FDI

utilization. As the world's largest FDI net outflow economy, the United States would see its GDP decline by 3.42 trillion dollars after disrupting global ownership-based trade; exporting to host economies through established affiliates (horizontal FDI) is an important way for the U.S. to gain benefits, and under the ownership-based trade accounting framework, this method is also recognized as U.S. exports to host economies. Disrupting ownership-based trade prevents the U.S. from benefiting through this channel. Although China is not the world's second-largest FDI net outflow economy, disrupting ownership-based trade would reduce its GDP by 2.96 trillion dollars, with the second-largest absolute decline globally. The main reason is that as the world's largest goods trading nation, China's total import-export volume accounted for 31.14%[1] of GDP in 2020, with a relatively high degree of foreign trade dependence. Disrupting global ownership-based trade would negatively impact China's exports to international markets to meet global demand and imports of international production factors to satisfy domestic needs, ultimately affecting economic growth. At the same time, China's strong domestic demand market and complete industrial supply chain system have increasingly attracted foreign capital, with actual FDI utilization reaching 144.37 billion dollars in 2020. Under the ownership-based trade accounting framework, the portion of foreign-owned enterprises' sales in China is regarded as exports from other economies to China. Disrupting global ownership-based trade would mean the termination of trade between foreign-owned enterprises in China and the domestic market, also impacting economic growth. Germany and Japan, both ranking among the top in global FDI net outflows, would suffer losses of over 1 trillion dollars in GDP if global ownership-based trade were disrupted.

5. Conclusions and Outlook

Based on the inter-country input-output tables and bilateral output flow tables distinguishing domestic and foreign ownership provided by OECD-AMNE, this paper further splits the foreign-owned sectors in the I-O tables using the fixed proportion assumption to obtain inter-country input-output tables distinguishing ownership. Based on this, it estimates the ownership-based trade flows of the global total and 12 key economies, and uses the hypothetical extraction method to simulate the potential impacts on global GDP and the GDP of 12 key economies in the scenario of global ownership-based trade disruption, leading to the following conclusions.

For the vast majority of economies, ownership-based trade flows are larger than territorial trade flows. Against the backdrop of rapid FDI growth, the ownership-based

[1] Data Source: https://data.stats.gov.cn

trade accounting framework can more comprehensively reflect the trade balance between two economies. Taking China and the United States as an example, in 2020, both China's ownership-based exports to the U.S. and the U.S.'s ownership-based exports to China were larger than those under the territorial principle. The trade surplus between China and the U.S. reached 2562.4 billion dollars under the territorial principle, but was significantly reduced to 1323.3 billion dollars under the ownership principle. Ignoring the trade of overseas affiliates between China and the U.S. under the territorial principle seriously overestimates the trade surplus.

Disrupting global ownership-based trade would have a negative impact on the global economy, and the degree of negative impact on each economy is closely related to its FDI flows and actual foreign capital utilization. In 2020, completely disrupting global ownership-based trade would reduce global GDP by 26 percentage points compared to normal trade. As the world's largest FDI net outflow economy, the United States would see its GDP decrease by 3.42 trillion dollars if global ownership-based trade were disrupted, suffering the highest negative impact. Due to China's high level of FDI net outflows and actual foreign capital utilization, disrupting ownership-based trade would reduce China's GDP by 2.96 trillion dollars, ranking second globally in terms of negative impact.

This study has the following limitations and shortcomings. In the process of obtaining inter-country input-output tables distinguishing ownership, only 12 relatively important global economies are currently split by ownership, and further expansion of the disaggregation dimensions is needed to focus on the ownership-based trade of other economies. At the same time, only the 2020 inter-country input-output tables distinguishing ownership are currently available, and future research should continue to expand the time dimension to provide a richer data foundation for empirical analysis. In the process of estimating ownership-based trade flows, future research should distinguish between final consumption and capital formation in the estimation of ownership-based trade in final goods, particularly by distinguishing the share of enterprises with different ownerships in each economy in the capital formation part, and further dividing the capital formation part by ownership based on the value-added shares of enterprises with different ownerships in each economy in the AMNE database, so as to more accurately account for ownership-based trade in final goods. When simulating the potential impacts of ownership-based trade disruptions, only the extreme scenario of complete disruption of global ownership-based trade is currently simulated. In future analyses, various scenario simulations can be conducted by incorporating actual conditions such as economies' trade protection policies to enrich the existing research.

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