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RE-EVALUATION OF CHINA'S ICT EXPORTS: A CROSS-COUNTRY COMPARISON

China's tremendous growth of exports is greatly attributed to the exports of ICT products. According to UNCTAD statistics, China has been the largest exporter of ICT products since 2004 and its share in global market has reached 29.1% in 2010. This paper re-evaluates the position of China's ICT exports in global market by comparing its generated domestic value added and accompanied carbon responsibilities in exports with the main advanced economies based the inter-country input-output data. The results show that until 2008 advanced countries were still responsible for less emissions than China when receiving the same value added in ICT exports, though China experienced much faster growth in terms of exports' volume and technology upgrade in carbon reduction. There is still a substantial gap between China and the key advanced countries in terms of received economic benefits and carbon reduction responsibilities.

Keywords: *domestic value added; carbon responsibility; ICT industry; China.*

JEL codes: C67; F14; Q56.

Шимей Янг, Юфанг Лію

НОВИЙ ПОГЛЯД НА КИТАЙСЬКИЙ ЕКСПОРТ ТОВАРІВ ІКТ: МІЖКРАЇНОВЕ ПОРІВНЯННЯ

У статті продемонстровано стрімке зростання китайського експорту в останні роки з акцентом на експорті товарів ІКТ (інформаційно-комунікаційних технологій). Починаючи з 2004 р. КНР є найбільшим у світі експортером товарів ІКТ, у 2010 р. частка країни у світовому експорті товарів ІКТ становила 29,1%. У міжкраїновому порівнянні експорту ІКТ акцент зроблено на таких параметрах як внутрішня додатна вартість та викиди вуглецю в атмосферу. Результати аналізу даних порівняння за групами країн (регіонам) показали, що до 2008 р. розвинені країни викидали в атмосферу менше вуглецю, ніж КНР, генеруючи при цьому таку саму внутрішню додану вартість. Хоча за останні два десятиріччя КНР продемонструвала значне зростання обсягів експорту та одночасний стрімкий розвиток технологій зменшення викидів вуглецю, різниця між Китаєм та розвиненими країнами у співвідношенні між економічними вигодами від виробництва всередині країни та викидами вуглецю все ще залишається значною.

Ключові слова: *внутрішня додана вартість; зобов'язання щодо викидів вуглецю; сектор ІКТ; Китай.*

Табл. 4. Форм. 4. Рис. 3. Літ. 26.

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НОВЫЙ ВЗГЛЯД НА КИТАЙСКИЙ ЭКСПОРТ ТОВАРОВ ИКТ: ПОСТРАНОВОЕ СРАВНЕНИЕ

В статье показан стремительный рост китайского экспорта в последние годы с акцентом на экспорте товаров ИКТ (информационно-коммуникационных технологий). Начиная с 2004 г. КНР является крупнейшим в мире экспортёром товаров ИКТ, в 2010 г. доля страны в мировом экспорте товаров ИКТ составила 29,1%. В межстрановом сравнении экспорта ИКТ акцент сделан на таких параметрах как внутренняя добавленная стоимость и обязательства по выбросам углерода в атмосферу. Результаты анализа данных сравнения по группам стран (регионам) показали, что до 2008 г. развитые

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страны выбрасывали в атмосферу меньше углерода, чем КНР, генерируя при этом сравнимую с Китаем внутреннюю добавленную стоимость. Хотя за последние два десятилетия КНР продемонстрировала значительный рост объёмов экспорта и одновременного развития технологий по уменьшению выбросов углерода. Разница между Китаем и развитыми странами в соотношении между экономической выгодой от производства внутри страны и выбросами углерода всё ещё остаётся значительной.
Ключевые слова: *внутренняя добавленная стоимость; обязательства за выбросы углерода; сектор ИКТ; Китай.*

1. Introduction

Due to deepening globalization and increased integration into the world economy, China has dramatically expanded its foreign trade from 38 bln USD to 2974 bln USD during the past 3 decades (1980–2010), at a considerable annual growth rate of 15.6%. A great deal of this outstanding performance is attributed to an impressive increase of international trade (Arto et al., 2013), especially the information and communication technologies (ICT). UNCTAD statistics show that China's ICT exports recorded the annual growth rate of 26.4% in 2000–2010, almost 5 times higher than the average world rate of 5.6%. As a result, its percentage in China's total exports increased from 17.7% in 2000 to 29.1% in 2010, with an opposite trend of world ICT export for which the share in total merchandise exports dropped from 15.9% to 11.8%. Moreover, there is evidence suggesting that China has upgraded the competitiveness of ICT exports, both in quantity and quality, as testified by the booming share in the world total increased from 4.4% to 26.6% in 2000–2010 (Amighini, 2005; Vogiatzoglou, 2009).

Given these facts, China has long been pursuing biased policies in its promotion of comparative specialization and exports of ICT products (Amiri et al., 2013). An often ignored aspect, however, is that the huge gross exports of ICT products from China do not necessarily indicate high economic benefits which China received from the global production. Recent products or firm studies (Antras, 2003; Antras, Helpman, 2004; Grossman, Helpman, 2004, 2005; McLaren, 2000; Feenstra, Hanson, 2005; Feenstra, Spencer, 2005) suggests that European, Japanese and US firms still capture major parts of value chains as they specialize in high value added activities such as software, design, branding, and system integration. China or other emerging countries are mainly involved in low value added and less technology-intensive activities such as assembling, testing and packaging that are poorly compensated. One typical well-known example is that China receives less than 2% of the retail price as income for its labor and capital employed in the assembly process of IPod while "Apple" captures 25% of the retail price compensated for its design and the US distributors capture another 25% for retail services (Linden et al., 2011). It seems that China should be less optimistic about its huge ICT exports when the actual economic benefits are considered.

Another often ignored aspect is the environmental impact induced by ICT exports. Carbon embodied in international trade has long been discussed since it causes a geographic separation between the carbon content of goods used or consumed in a country (i.e., consumer-based responsibility) and the carbon emitted by a country in the production of goods and services (i.e., producer-based responsibility).

Yan and Yang (2010), for example, estimated 10.0–26.5% of China's CO2 emissions are generated due to the manufacture of exports destined for foreign consumers (in 1997–2007). Although ICT products are thought to be relatively "clean", its downstream production of input materials is to some extent carbon-intensive (Fettweis, Zimmermann, 2008). Jiang and Liu (2013) found the growth of total CO2 emissions embodied in China's exports after 2002 are greatly due to ICT products. This is not surprising since ICT contributed largely to the booming exports of China.

It is therefore very interesting to (re-)evaluate China's ICT exports from both the actual value added which China adds in international production and the embodied carbon emission which China is responsible for exported ICT goods destined to foreign consumers. The cross-country comparison is thus introduced among China and advanced countries/regions that are actively involved in the global ICT production chain, such as US, EU, Japan, Korea and Taiwan. In spite of the vast literature on the DVA contents and the carbon embodied in China's exports respectively (Chen et al., 2004; Lau et al., 2006; Zhang et al., 2012; Koopman et al., 2012) for DVA measurements of China's exports; and Ahmad and Wyckoff, 2003; Ashton and Wang, 2003; Peters et al., 2007; Weber et al., 2008 and Dietzenbacher et al., 2012 – for carbon measurements of China's exports.), there is not much literature – as far as we know – to discuss both the value added and the embodied carbon for ICT exports based on a harmonized database. More specifically, an inter-country input-output database WIOD (World Input-Output Database) is employed to compare the value added and the carbon generated for countries/regions along the entire global ICT production chain.

2. Methodology

Both the value chain and the embodied carbon emissions in international trade has attracted a great deal of academic interest in recent years. The input-output technique is widely accepted since it can depict both the inter-country and intra-industry flow of the global production process. As a result, the indirect effects, for example, for Japan from the sale of 1 iPod in the US, can be measured by describing Japan as the components supplier of the iPod assembling activity in China. Table 1 outlines the scheme of the inter-country input-output tables. The diagonal matrices of intermediate use give domestic intermediate deliveries. The elements Z_{ij}^{11} of matrix Z^{11}, for example, give the domestic (or intra-country) intermediate deliveries from industry i in country 1 to industry j in country 1, with $i,j = 1,...,n$, where n is the number of industries. The non-diagonal matrices give the inter-country intermediate deliveries. The elements Z_{ij}^{1m} of matrix Z^{1m}, for example, give the deliveries of products from industry i in country 1 for input use in industry j in country m. The matrices of final demand have similar fashion. In contrast to the national input-output table where exports are listed as an individual column, the exports in inter-country input-output table are separated to several columns in intermediate and final use. The exports of country 1, for example, is the sum of $\Sigma_{k=2,...,m}Z^{1k}$ and $\Sigma_{k=2,...,m}F^{1k}$.

Direct input coefficients then can be obtained by normalizing the industry columns in the IO table, that is:

$$a_{ij}^{rs} = \frac{z_{ij}^{rs}}{x_j^s}$$

with $r,s = 1,...,m$, where m is the number of countries and $i,j = 1,..,n$, where n is the number of industries.

Table 1. **The inter-country input-output table**

			Intermediate use			Final use			Total output
			Country 1		Country m				
			Industry 1,.., n	...	Industry 1,...,n	Country 1	...	Country m	
Interme-diate use	Country 1	industry	Z^{11}	...	Z^{1m}	F^{11}	...	F^{1m}	X^1
	...	...	...	...	...	...	...	...	...
	Country m	industry	Z^{m1}	...	Z^{mm}	F^{m1}	...	F^{mm}	X^m
Value Added			V^1	...	V^m				
Total Inputs			X^1	...	X^m				

Define the complete input coefficients matrix

$$A = \begin{pmatrix} A^{11} & A^{12} & ... & A^{1m} \\ A^{21} & A^{22} & ... & A^{2m} \\ ... & ... & ... & ... \\ A^{m1} & A^{m2} & ... & A^{mm} \end{pmatrix}$$

with A^{rs} is the input coefficients from country r to country s, and corresponding final demand $F = (\Sigma_{k=1,...,m}F^{1k}\ \Sigma_{k=1,...,m}F^{2k}\ ...\ \Sigma_{k=1,...,m}F^{mk})'$ with F^{rs} is the final use from country r to country s and the total output $X = (X^1\ X^2\ ...\ X^m)$ with X^r is the sectoral outputs of country r, the basic input-output equilibrium (row-wise) can be expressed as:

$$X = AX + F \tag{1}$$

The Leontief inverse $B = (I - A)^{-1}$ now includes both direct and indirect linkages of inter-country and inter-sector. Assume country r increases its imports from country 1 ΔF^{1r} as final demand (i.e. country 1 increase its exports to country r), all the countries should increase their outputs to satisfy this extra demand, that is

$$\Delta X = (I - A)^{-1}\Delta F, \tag{2}$$

where $\Delta F = (0,...,0,\Delta F^{1r},0,...,0)'$. By looking at the equation (2), it is very evident that other countries (neither country 1, nor country r) would still benefit by involving in the global production process, even though their own final demand is unchanged. Benefits, however, vary with the extent to which the country involves in the global value chain. The exports of iPod from the US to South Africa, for example, would bring domestic value added to the US, China, Japan and South Korea, while DVA contents are different for each of these country. In a similar vein, carbon emissions would be generated in each country along the global production chain.

The domestic value added of country r generated by ICT products exports in country s can be derived as:

$$V^{rs} = VA^r(I - A)^{-1}EX^s_{ICT} \tag{3}$$

where A is the input coefficients matrix with $m*n$ dimension at both the country and the industry level; VA^r is the row of value added coefficients with $m*n$ dimension as well, and we have $VA^r = (0,...,0,va_r,0,...,0)$ where va_r is the value added coefficients row of country r with n dimension at the industry level; EX^s_{ICT} is the column of exports in ICT products with $m*n$ dimension, and we have $EX^s_{ICT} = (0,...,0,ex^s_{ICT},0,...,0)'$, where $ex_{ICT}^{s} = \sum_{k=1}^{k \neq s} f_{ICT}^{sk}$ is the total export of ICT products from country s to other countries as final demand. It should be noted that the exports from country s used as intermediate use of other countries $\sum_{r=1,\ldots,m}^{k \neq s} Z_{ICT}^{sr}$ lead to indirect economic benefits which country s received from the exports of other country r ($r = 1,\ldots,m$ and $r \neq s$). The total value added generated by the exports of country s, therefore is exactly the same for the single country and an inter-country input-output table, while the inter-country table outperforms single-country table by providing clear road map how the value added is generated in different countries along the global value chain of ICT production.

Similarly, carbon emissions generated in country r by exports of ICT products in country s is:

$$E^{rs} = CA^{r}(I - A)^{-1}EX^{s}_{ICT} \qquad (4)$$

where A and EX^{s}_{ICT} have identical definitions in (3) and CA^{r} is the row of carbon emission coefficients with $m*n$ dimension and $CA^{r} = (0,\ldots,0,ca_{r},0,\ldots,0)$, where ca_{r} is the carbon emission coefficients in per unit output of country r with n dimension at the industry level. Both direct carbon emission in producing the end-use ICT products and the indirect carbon emission in producing inputs (i.e. materials) for the end-use ICT products are measured in calculation, since the Leontief inverse here is describing the entire global production chain at the inter-country as well as the inter-industry level.

As mentioned above, the newly released World Input-Output Database (WIOD), which covers 40 countries and 57 sectors from 1995–2009 (Timmer et al., 2012), is used for empirical calculations. To highlight the analysis, we aggregate the countries/regions into 4 major economic zones to be compared with China, that are advanced economies – EU-27, NAFTA (including United States, Canada and Mexico), East Asia (including Japan, South Korea and Taiwan) and a club of other major emerging markets BRIIAT (Brazil, Russia, India, Indonesia, Australia and Turkey). In addition, although the WIOD presents time series from 1995 through 2009, our analysis only covers the period from 1995 to 2008, as in 2009 the global financial crisis obscured the development of ICT.

3. Results

3.1. Trend in ICT products exports

Before we present the results of value added and carbon distributions, we first provide some basic descriptions of the world ICT exports. On Figure 1 we depict the growth of the world ICT exports both used as intermediate inputs and final demand in 1995–2008 as shown in WIOD. Please, note the WIOD data is to some extent different from the UNCTAD statistics since they differ in the "sector" definition. The sector 14 "Electrical and Optical Equipment" in WIOD is regarded as ICT sector in this paper. The total export volume of ICT products witnessed considerable growth from 635 bln USD in 1995 to 2125 bln USD in 2008, with the annual growth rate at 9.0%. This growth is dominated by the exports of intermediate products: the exports of ICT components and parts (for intermediate use in other countries) are only 43 bln USD more than the export of end-use ICT products (final demand of other countries) in 1995, and until 2008 this gap reached 422 bln USD. The annual growth rates of the ICT components exports and parts and end-use ICT products are 9.9% and 7.8%, respectively.

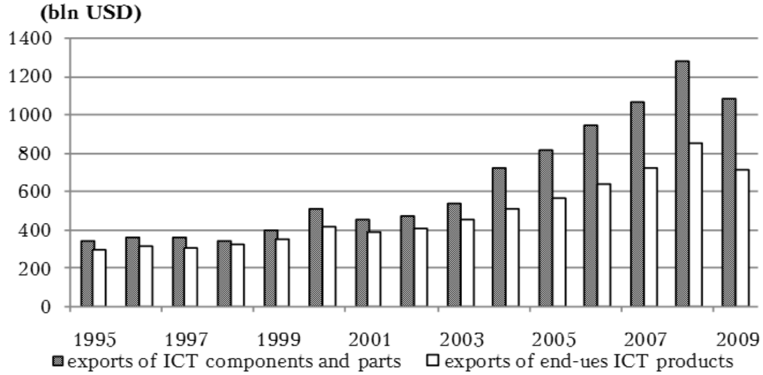

Figure 1. **The global exports of ICT products (1995–2008)**

Figure 1 gives the shares of both ICT components and end-use ICT products. As already mentioned, China has significantly expanded its shares at the world ICT market during the past decade, in particular at the components and parts market. China's share of the world ICT components exports increased from 4.3% in 1995 to 28.6% in 2008, for which the shares of advanced countries are largely shrunk. Meanwhile, East Asia's exports share dropped from 31.0 to 23.0%, the NAFTA share eroded from 18 to 10%, and the EU fell from 27.6 to 22.4%. The BRIIAT maintained a 1.6–2.0% share.

The world end-use ICT products exports changed even more sharply. Since 1995, China's twentyfold expanded its exports of end-use ICT products from 19 bln USD in 1995 to 386 bln USD in 2008, for which reason its share expanded from 6.5 to 45.4%. As a result, the shares of all other countries significantly reduced. East Asia share dropped from 25.3 to 12.0%, while NAFTA share fell from 14.7 to 7.8% and the EU share eroded from 31.9 to 22.7%. The BRIIAT share increased slightly from 1.6 to 2.9%. It should be noted here that ICT products of foreign-funded enterprises in China account for about 70% of China's total ICT exports in 2008. It is very possibly that multinational enterprises and their "own" trade, which import a great amount of intermediate inputs from their home country to assemble its end-use exported products in another country, actually lead to these changing patterns.

3.2. Domestic value added (DVA) of end-use ICT exports by regions

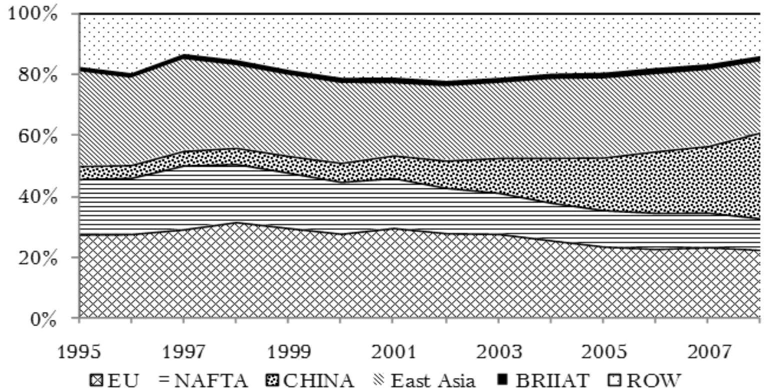

Figure 2. **Exports of ICT parts and components by regions**

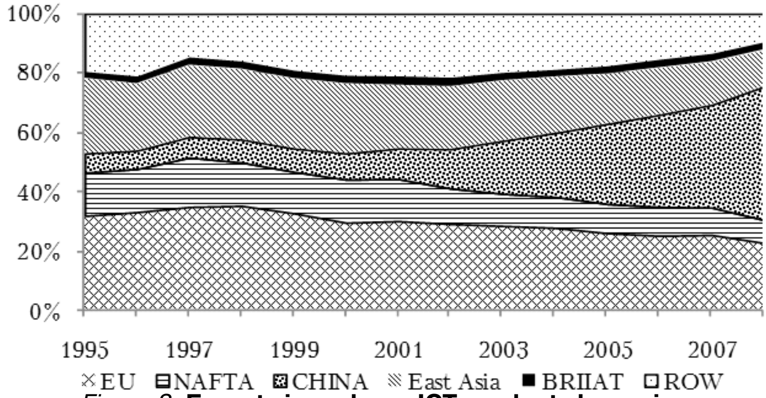

Figure 3. **Exports in end-use ICT products by regions**

Figures 2 and 3 describe how the distribution of economic benefits in end-use ICT exports from each region changed during 1995–2008. Since the world exports of end-use ICT products experienced a continuous increase during 1995–2008 (shown on Figures 2 and 3), in this section our attention is paid only to the results for the first year (1995) and the end year (2008). The number in the second column in Table 2, for example, depicts how much domestic value added (DVA) each region/country (shown in different rows) received from the EU exports of end-use ICT products in 1995. In addition, the contributions of exports in ICT parts and components are reflected by indirect economic benefits, e.g. China gained 17 bln USD from the EU export in 2008, by providing intermediate inputs (incl. ICT components) to the production of the EU exported end-use ICT products.

Table 2. **Value added generated in exports of end-use ICT products, by regions**

Regions which receive value added (in bln USD)	The exporting regions									
	EU-27		NAFTA		East Asia		China		BRIIAT	
	1995	2008	1995	2008	1995	2008	1995	2008	1995	2008
EU-27	189508	289315	7735	9792	5223	8879	1279	34749	2594	6513
NAFTA	8605	13475	176584	238033	9314	9834	1289	27931	1468	2899
China	1014	17250	1032	13006	1497	12792	30281	291825	208	4351
East Asia	6347	10575	11154	8491	231524	161924	3998	61187	1482	3078
BRIIAT	2365	8634	1174	3518	2118	4953	550	17055	34577	83213

The first observation of Table 2 is that both the total and the domestic value added generated in end-use ICT exports increased over time for all the regions under study in absolute terms, except East Asia, while China increased the most. These trends are totally in line with the patterns of the world ICT shown in Table 2. Fuelled by the expanded share from 6.5 to 45.4%, China's DVA in its own end-use ICT exports increased from 30 bln USD to 292 bln USD. Correspondingly, the remaining regions such as NAFTA and EU grow much slower than China in terms of DVA in their own end-use ICT exports. There is even a decrease of value added in the exports of East Asia, for which the market share shrunk the most. In terms of the absolute value of indirect economic benefits, China is also a big "winner". In 1995, the value added China gained through exports of other countries is only 7 bln USD, until 2008 it has reached 141 bln USD, accounting for 29.3% of China's total value added received from the world ICT exports. Again, this is largely due to the expanded share of China's exports in ICT parts and components (from 4.3 to 28.6%).

The second observation is that DVA contents became less from 1995–2008 when it is counted in relative percentage instead of absolute value, especially for China. In 1995, China could capture 78% of the total value added generated in China's own exports (30 bln USD vs. 39 bln USD), until 2008, this ratio has dropped to 61% (292 vs. 480 bln USD), reduced by 17%. In a similar way, DVA contents of East Asia dropped 15%, while NAFTA, EU and BRIIAT fell about 5–10%. Among others, the increasing fragmentation of production should be recognized as the most important reason. More imports of intermediate inputs (incl. ICT parts and components) lead to lower DVA content which the country received from its own exports.

Another interesting finding of Table 2 is that the countries have different patterns in terms of inter-country linkages. The drops of DVA contents which EU and NAFTA obtained from their own exports are mainly attributed to China. In contrast, the drops of DVA contents which East Asia obtained from its own exports are attributed to NAFTA, EU and China simultaneously. All the remaining regions (EU, NAFTA and East Asia) obtained much more indirect share from Chinese export. Since WIOD failed to separate ownerships, there is a very real possibility that the value added which China received via the EU exports is captured by the EU-invested enterprises in China. See (Timmer et al., 2012) for the similar argument when discussing the capital income: "With high FDI flows from advanced to emerging countries, part of the capital on these countries' territory is owned by firms headquartered in advanced nations". Duan et al. (2012) showed that every 1000 USD of China's exports generates about 700 USD of domestic value added in 2007 and among them about 500 USD is national income and 200 USD is the income of FIEs in China. Following this logic, one of the underlying reasons behind the changing patterns of inter-country linkages is that multinational ICT enterprises and their voluntary relocations. By investing and relocating to China, advanced economies of the EU, NAFTA and East Asia received even higher shares of value added in China exports.

3.3. Carbon emissions embodied in the end-use ICT exports by regions

Table 3. **Carbon generated in the exports of end-use ICT products, by regions**

Regions which emit carbon (in mln tons)	Exporting regions									
	EU-27		NAFTA		East Asia		China		BRIIAT	
	1995	2008	1995	2008	1995	2008	1995	2008	1995	2008
EU-27	60573	47111	4049	2975	2966	2417	752	8945	1382	1967
NAFTA	5317	4511	86778	52851	6316	3375	943	10098	1030	1231
China	4750	26425	4949	20603	7330	21576	126412	427543	954	7216
East Asia	1982	4323	3514	3665	55479	49956	1557	24738	564	1481
BRIIAT	5314	8792	3296	4159	5784	5738	1367	17906	43672	61501

In a similar way, Table 3 describes how carbon emitted in the world ICT exports from each region changed during 1995–2008, see (4). In spite of the exports growth, the reduction of carbon emissions intensity in per unit end-use ICT exports lead to the overall decrease of domestic carbon emissions in advanced countries (EU, East Asia and NAFTA). Emerging economies, especially China, however, show increases of domestic carbon emission, mainly due to their explosive growth of exports. China's end-use ICT exports increased 12 times from 1995 to 2008, while the exports of advanced countries increased only 70%.

According to Table 3, China and the emerging economies of BRIIAT are responsible for most of the carbon emissions generated in their own end-use ICT exports, whereas this is not true for advanced countries. In 2008, China is supposed to be responsible for 428 mln tons of carbon, accounting for 82% of the total carbon emissions generated in China's end-use ICT exports. The EU is responsible for 47 mln tons of carbon, accounting for only 45% of the total carbon emissions generated in the EU end-use ICT products. This is mainly due to differences in carbon emission intensities. Emerging countries still have generally higher emission intensities (e.g., BRIIAT at 2.25 and China at 1.11 ton/ths) than advanced countries in 2008 (e.g. NAFTA at 0.80, East Asia at 0.49 and EU at 0.24 ton/ths), which leads to that the overall emissions are much more even they produce the same volume of exports and subsequently domestic emissions shares are higher than the value added contents in per unit exports.

It is thus very interesting to compare the differences of value added and carbon generated in per unit world ICT exports for each region in Table 4.

Table 4. **Comparisons of exports, value added and carbons in the world ICT exports*, %**

	Annual change rate (1995-2008)					2008	
	exports of ICT industry	value added in exports	carbon in exports	Value coefficient	Carbon intensity	value coefficient	carbon intensity
EU-27	5.2	3.7	1.2	-1.5	-3.8	1.84	0.54
NAFTA	3.1	2.4	-1.4	-0.7	-4.3	4.25	1.38
East Asia	2.2	-1.3	0.6	-3.4	-1.6	2.09	0.92
China	23.8	19.7	10.3	-3.4	-11.0	1.24	1.36
BRIIAT	10.4	6.9	3.4	-3.1	-6.3	5.46	4.10

* both direct and indirect effects are included.

The first 3 columns compare the annual change rates of exports, the embodied total value added and emission for each region during 1995—2008. It is found that emerging countries especially China grow much faster than advanced countries in terms of "sizes", including exports and embodied value added or carbon emissions. There are even declines of the value added which East Asia received from exports and emissions which NAFTA was responsible for the exports shown as negative signs. The following two columns are the indicators for per unit exports, showing that emerging countries decrease faster than advanced countries in terms of both emission intensity and value added coefficients. Note that any region/country generally prefers more value added but less embodied carbon emissions, similar trends then have totally opposite meanings. China and the emerging countries of BRIIAT would receive less value added than advanced countries if they exported the same ICT products, in spite they reduce more carbon emission than advanced countries simultaneously. This must be also related to the above mentioned FDI flows and the activities of multinational enterprises: advanced countries relocated some productions of low value added to emerging countries such as China through FDI, leading to the results that exports and embodied value added of China grow faster. Meanwhile, there is also an accompanied technology spillover via FDI, leading to much more substantial declines of carbon intensities in China.

In the last two columns of Table 4 we compare the total value added (in 1000 USD) and emissions (in ton of carbon dioxide) per 1000 USD of region's own export in 2008. By including both direct and indirect effects, it suggests substantial "inequalities" among advanced countries and emerging countries until 2008. For example, if China export 1000 USD of end-use ICT products, it would gain 1360 USD of domestic value added but is responsible for 1240 tons of carbon emissions. With same 1000 USD of end-use ICT exports in the EU would gain 1840 USD of domestic value added and be responsible for 540 tons of carbon emissions. This difference generally holds for all emerging and advanced countries. Moreover, if we divide the value added coefficients to emission intensities, the results show that advanced countries are responsible for only 300—450 tons of carbon emission when receiving 1000 USD of value added, while emerging countries need to be responsible for 750—1110 tons of carbon emissions when receiving the same value added.

4. Conclusions

Based on the harmonized inter-country input-output database of WIOD, we compare patterns and changes of value added distributions and carbon emission responsibilities of the ICT exports for China and main advanced and emerging economies in 1995—2008. Both direct effects due to the productions of regional/national own exports and indirect effects due to downstream productions of intermediate inputs of other region/country's exports are considered.

The results show that the increasing role of China in the international fragmentation of ICT production indeed significantly changed the patterns at the global ICT market. China expanded significantly in its exports of both intermediate and end-use ICT products. As a result, China's domestic value added due to its own exports of end-use ICT products grow more than nine-fold from 30 bln USD in 1995 to 292 bln USD in 2008, and its indirect value added due to the supply of intermediate inputs to other region/country's exports expanded more than 20 times from 7 bln USD to 141 bln USD. The emerging economies of BRIIAT also have rather good performance in terms of sizes, by showing about threefold growth of both domestic and indirect value added. The remarkable growth of China and emerging economies thus shrunk the shares of the remaining regions such as NAFTA and EU, and as a result their growth of domestic and indirect value added from the global ICT exports do not reach a double in 1995—2008, and there is even a decrease of value added for East Asia, for which the market share shrunk the most.

When it comes to the carbon embodied in exports and the relative shares, the pictures are quite different. Our measurements suggest that domestic value added due to country/region's own exports shrinks and indirect value added due to the supply of intermediate inputs to other region/country's exports expanded for China. On the contrary, domestic value added shares of country/region's own exports are relatively stable for advanced countries. In terms of carbon emission, it is found that emerging countries, especially China, reduced much more carbon intensity in per unit exports than advanced countries during 1995—2008. However, until 2008 advanced countries are still responsible for less emissions but receive more value added, even they export the same amount as ICT products. There is substantial inequality in terms of received economic benefits and carbon responsibilities between China and advanced economies. If we further consider FDI flows and the existence of widespread multinational enterprises, this inequality of economic benefits due to international trade become even more serious. The current trade statistics seems to highly overlook the economic benefits which China received from ICT exports, with obvious ignoring the environment burden which China is responsible for the ICT exports destined to foreign consumers.

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