Regional Cooperation and the Environment: Do "Dirty" Industries Migrate?

By

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I. Introduction

The intellectual history of trade and the environment has evolved in two waves (Levinson 1996). The first wave of research peaked in the late 1970s and seems to have been inspired by the introduction of stringent environmental regulations in developed countries from the early 1970s. The second wave occurred in the 1990s, mainly motivated by the debate over international trade agreements such as the North American Free Trade Agreement (NAFTA) and the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). The current debate involves significant issues relating to environmental protection, export competitiveness, industry migration, and the use of environmental regulations as nontariff trade barriers including eco-labeling (Bhagwati and Hudec 1996; Dean 1992). Although the policy debates relating to NAFTA and GATT may have subsided, fundamental long-term issues of trade and the environment remain.

Concerns have been expressed about how differences in national environmental regulations might have implications on industry location decisions and patterns of international trade (Low and Yeats 1992). If free trade occurs between countries with different environmental standards, will 'dirty industries' migrate from countries with higher environmental stringency to countries with lower environmental stringency? Will countries with lower environmental standards tend, over time,

Remark: We are grateful to Peter Drysdale, Neil Vousden, Kali Kalirajan, Ben Smit, and an anonymous referee for their constructive comments and suggestions. We also thank our discussant, Shigeyuki Abe, and seminar participants at Kobe University and Australian National University joint seminar "Australia, Japan and APEC" in Kobe, Japan, for their comments and suggestions. The remaining errors are our own responsibility.

to develop a comparative advantage[1] in environmentally sensitive industries with the result that 'havens' for the world's dirty industries emerge? (Cropper and Oates 1992).

Studies examining directly the effects of changing abatement costs on trade flows of Environmentally Sensitive Goods[2] (ESGs) generally follow one of the following three approaches. The first is the trade-in-goods approach in which trade patterns of ESGs are explored explicitly, for example, Siebert (1977; 1987), Siebert et al. (1980), Tobey (1990), Kalt (1988), Grossman and Krueger (1993), Van Beers and van den Bergh (1997), Low and Yeats (1992), Sorsa (1994), and Xu (1999b). The second is the factor-content-of-trade approach in which trade in factor services is investigated (Walter 1973; Robison 1988). The final approach is to examine effects on investment decisions of changes in environmental regulations using firm-level data, for example, Leonard (1988).

This study builds on the work by Walter (1973) and Robison (1988) but goes beyond their studies by two major innovations. We first develop an alternative method to investigate trade in embodied environmental factor services. We then apply this method to bilateral (instead of multilateral) trade between Asia Pacific Economic Cooperation (APEC) economies. We ask the following question: Do 'dirty industries' migrate along with the deepening of regional cooperation? This issue is investigated through trade in embodied environmental factor services among APEC economies in the last two to three decades. If "dirty industries" do migrate from countries with higher environmental standards to countries with lower environmental standards along with the deepening of regional cooperation, we will be able to observe, through trade data, systematic changes in patterns of embodied environmental factor services. This will be so, especially in the APEC region where economies are in different stages of economic development and where diversity in environmental regulations is a norm.

The rest of the paper is organized as follows. The following section reviews the received literature on trade in environmental factor services. Section III discusses the data and methodology in this study. A comparison of different approaches is provided in Section IV. Section V reports the result and the final section concludes.

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[1] See Warr (1994) for a comparison of the concept 'comparative advantage' and 'competitiveness'.

[2] ESGs and 'dirty' industries (goods) are used interchangeably in this paper. These industries incurred higher pollution abatement and control expenditures as to their total sales. For a detailed definition, see Low and Yeats (1992) and Xu (1999a).

II. Trade in Embodied Environmental Factor Services: The Literature

In the literature of trade and environment, the environment (for example, pollution) is generally conceived of as a by product of the production and/or consumption of ESGs, or it is treated as a factor of production. The conventional textbook approach to environmental economics adopts the former approach (Baumol and Oates 1988). In this context, pollution is due to externalities that arise as a result of the production and/or consumption of ESGs. The result of these externalities is to drive a 'wedge' between the private and social marginal cost of production. This 'wedge' can then be corrected through a Pigovian tax-cum-subsidy scheme.

However, the idea that the environment should be treated as a factor of production can be traced to Coase's well-known paper (Coase 1960). In his paper, Coase showed that, even if the Pigovian tax is exactly adjusted to equal the damage that would be done to society as a result of the negative production externality, the tax would not necessarily bring about Pareto-optimal solutions. This interesting finding leads Coase to insist on a change of approach so that the environment is treated as a factor of production. "If factors of production are thought of as rights, it becomes easier to understand that the right to do something which has a harmful effect (such as the creation of smoke, noise, smells, etc.) is also a factor of production" (Coase 1960: 44).

It is well known that international trade in goods can be interpreted as indirect flows of factor services. Thus, international trade in ESGs can also be interpreted as indirect flows of environmental factor services if the environment is treated as a factor of production. It would be interesting to investigate the trade patterns of embodied environmental factor services across a range of countries over time to see whether 'dirty' industries have migrated.

The concept of trade in embodied environmental factor services, where pollution is the environmental factor, captures the idea that traded goods embody an environmental factor service. It reflects the amount of pollution emitted domestically for goods produced for export. The relevance of this concept in investigating the trade effects of environmental policy lies in the fact that the factor-content-of-trade approach is an alternative to the trade-in-goods approach. A simple example (applying the Heckscher–Ohlin (H–O) Theorem) is that if countries have different domestic environmental policies, their ability to pollute or their abundance of environmental services might

differ.[3] In the resulting trade pattern, one would expect countries with stringent environmental regulations to have more embodied environmental factor services in their imports than in their exports, while countries with less stringent environmental regulations might reveal the opposite pattern.

There are few studies in the literature so far that look at trade in embodied environmental factor services. In one of the earliest studies, Walter (1973) looks into the pollution content of US trade. The question Walter asks is whether environmental-control charges actually incurred by industry form an essentially trade-neutral pattern, or whether they are fundamentally export-biased or import-biased. Walter calculates direct and overall environmental-control (including those from intermediate goods) charges for 83 goods and services categories contained in the 1966 US input–output table. The environmental-control cost (ECC) is approximated using the estimated direct and indirect costs attributable to environmental management which include current R&D expenditure for compliance, depreciation on current pollution abatement equipment, the capital cost of that equipment, and current operating costs associated with environmental management.

The estimated ECC per dollar of sales, together with the input–output coefficients, is then used to calculate the direct and overall ECC for each of the 83 sectors. The resulting estimates are multiplied by the average annual export (import) value for each sector and the summation across 83 sectors gives the pollution content of US exports (imports).[4] The pollution content of US exports is found to be 1.75 per cent of total exports while the pollution content of US imports is found to be 1.52 per cent of total imports. Walter interprets this difference to be insignificant, and concludes that ECCs are trade-neutral at best and marginally biased against US export industries at worst.

Another study that investigates trade in embodied environmental factor services is Robison's work (1988). He also looks into the pollution content of US trade for 1973, 1977, and 1982 using input–output tables for 1973 and 1977. This discrete time-series result indicates that the ratio of the abatement content of US imports to US exports has risen from 1.151 in 1973, to 1.167 in 1977 and 1.389 in 1982. On the basis of this result, Robison concludes that "there is some evidence that

[3] We assume the same assimilative capacity, and social preference, but focus on differences in environmental regulations.

[4] One should note that the same ECC coefficients are used for both exports and imports when ideally foreign trade partners' ECC coefficients should be used for the pollution content of US imports.

US pollution control programs have changed the US comparative advantage such that more high-abatement-cost goods will be imported and more low-abatement-cost goods exported". This result differs from that of Walter (1973). Walter's study shows that the ratio of abatement content of US imports to US exports in 1968–1970 is 0.812,[5] which indicates that the United States exports more environmental factor services than it imports.

III. Embodied Environmental Factor Services: Data and Methodology

In this section, the idea of the factor content of trade is introduced and a modified version is derived for the estimation in the next section. The factor content of trade approach was first employed by Leontief (1953) in his well-known test of the H–O Theorem and later formalized theoretically by Travis (1964), Vanek (1968), Melvin (1968), Deardorff (1982) and empirically tested by Leamer (1984), Song (1996) and many others.

We consider a world in which l primary factors combine to produce m goods in n countries. Factors cannot be traded but goods can. A country's consumption, exports and imports are described by the following vectors: $C^j = (C_1^j, \ldots, C_m^j)$, $X^j = (X_1^j, \ldots, X_m^j)$ and $M^j = (M_1^j, \ldots, M_m^j)$ are m-dimensional vectors of final consumption demands for goods in country j, exports and imports of country j, respectively; and $T^j = (T_1^j, \ldots, T_m^j)$ is an m-dimensional vector of country j's net exports. Elements of T^j will be negative for goods which are net imports. A country's net export vector can then be written in the following form:

$$T \equiv X - M . \tag{1}$$

We then define V^X, V^M, V^T and V^C as the actual quantities of factors embodied in X, M, T and C, respectively. Constant returns to scale and no joint production are assumed so that techniques of production can be represented by the amount of inputs used per unit of output of each good. Various production techniques can therefore be represented by the input–output coefficient matrices $A(w)$, where a_{hi} denotes the direct-plus-indirect requirement of factor h per unit of output of good i.

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[5] This number is calculated using the average annual overall environmental control loadings of US imports during the 1968–1970 period, that is, US$751 million, divided by that of US exports during the same period, that is, US$609 million.

The factors embodied in X are equal to

$$V^X = A(w)\,X \tag{2}$$

and the factors embodied in M are

$$V^M = A^*(w^*)\,M\,, \tag{3}$$

where a foreign country's input–output coefficient matrices are distinguished by asterisks. Note that if the countries have homogeneous, identical technology and factor prices are equalized, we obtain

$$A(w) = A^*(w^*)\,.$$

If pollution is treated as one type of environmental factor service, the pollution intensity can be measured using the input–output coefficients, $A(w)$, for each sector. Then, the factor content of trade[6] for each country can be calculated using the following equation:

$$V^T = V^X - V^M = A(w)\,X - A^*(w^*)\,M\,. \tag{4}$$

Since detailed sectoral pollution intensity data for trading partners (except the United States) are generally not available, we follow Walter (1973) and Robison (1988) by assuming that US pollution intensity can be applied to other countries. This is not a harmless assumption, however, because it could lead to an underestimation of the pollution content of exports for countries with lower environmental regulations than the United States, and an overestimation of pollution content of exports for countries with higher environmental regulations than the United States. In the case of imports, this can also lead to an underestimation of the pollution content of imports for countries with higher environmental regulations relative to their trading partners. This point must be borne in mind when providing interpretations of the pollution content of trade for a particular country.

Equation (4) becomes

$$V^T = V^X - V^M = A(w)^{US}\,X - A(w)^{US}\,M\,, \tag{5}$$

where $A(w)^{US}$ denotes the pollution intensity matrix in the United States.[7]

Two problems arise when one tries to apply real world data to (5). First, changing values of exports and imports for a country may simply

[6] This is one of the three versions of the factor content of trade specified in Deardorff (1982).

[7] Both Walter (1973) and Robison (1988) make use of this equation in their studies.

be due to export or import price changes without any real changes. The use of value rather than volume of exports and imports may, therefore, bias the result as was the case in Walter (1973). Second, a macroeconomic imbalance, such as a persistent national saving and investment imbalance, may lead to substantial changes in net exports without any structural implications.[8] For example, the United States experienced persistent current account deficits, with current account deficits as a percentage of GDP at 3.70 in 1987 and an annual average of 2.0 in the 1980s.[9] It is obvious that these effects need to be removed if meaningful results are to be derived.

We therefore propose to modify (5) as follows.

$$V_{jt}^{T} = \sum_{i} \left(\frac{a_i^{US} X_{ijt}}{\sum_{i} X_{ijt}} \right) - \sum_{i} \left(\frac{a_i^{US} M_{ijt}}{\sum_{i} M_{ijt}} \right). \tag{6}$$

where i is sector i, j is country j, t is year t, a_i^{US} is the pollution intensity index measured by the LAHTI (the definition follows below) index for the United States, X_{ijt} is sector i's exports for country j in year t, M_{ijt} is sector i's imports for country j in year t, and V_{jt}^{T} is the factor content of trade for country j in year t.

This modification takes into consideration the above two problems. Instead of using the export value for country j in year t, the export share of sector i for country j in year t is used. This abstracts away the inflation effect if it is an across-the-board increase in the prices of all commodities. The assumption of a uniform across-the-board price increase is equivalent to deflating the export value by the export unit value index, an approach commonly adopted in applied trade analysis. As will be argued later in this study, this modification also removes the effects of macroeconomic imbalances such as current account deficits. A one per cent increase in exports spreads uniformly across all goods (for example, when domestic savings are greater than domestic investment) and will not affect the level of V_{jt}^{T}. This method distinguishes this study from those of Walter (1973) and Robison (1988). The significance of this modification will be discussed in the next section.

In order to capture the changing patterns of the pollution content of trade for each country in the last 26 years, a normalization is carried out

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[8] For example, factor endowment changes.

[9] This is calculated on the basis of data from *World Development Indicator* 1997, World Bank and International Economic Databank, the Australian National University.

so that the pollution content of net exports for each country in 1970 is normalized to unity.[10] Depending on the initial condition, this normalization can yield a positive or negative unity. A positive sign indicates that this country's exports are more pollution-intensive than its imports. The reverse holds for a negative unity. From a time-series perspective, starting from a positive result in year 1970, a number greater than one, say 1.3, in the later years, $t = 1970 + n$ with $n = 1, \ldots, 26$, indicates that the pollution content of exports for country j in year t is 1.3 times as great as that in 1970. A change of sign indicates a structural change in the pollution content of trade.

To explore further whether there are structural changes on the patterns of embodied environmental factor services trade, the import content of embodied environmental factor services trade, as measured by

$$V_{jt}^{M} = \sum_{i} \left(\frac{a_i^{US} M_{ijt}}{\sum_{i} M_{ijt}} \right) \tag{7}$$

is then divided by the export content of embodied environmental factor services trade, as measured by

$$V_{jt}^{X} = \sum_{i} \left(\frac{a_i^{US} X_{ijt}}{\sum_{i} X_{ijt}} \right). \tag{8}$$

That is,

$$I_{jt} = V_{jt}^{M} / V_{jt}^{X}. \tag{9}$$

An index of greater than unity, $I_{jt} > 1$, indicates that country j's imports are more pollution-intensive than its exports in year t while an index of

[10] The normalization is carried out mainly for exposition purpose. Since the indicator, V_{ij}^{T}, is an index, normalizing the base year to one would help the exposition (like any other index, for example consumer price index). Although this normalization is useful in interpreting the changing pattern of pollution content of trade (as explained in the following text), it may not be helpful, if not confusing, in cross-country comparison. A country starting with a very small net factor trade which has been normalized to one and declining to zero would show up as a move from one to zero. On the other hand, a country starting with a very large net factor trade and decling to zero would also show up as a move from one to zero. However, both changes represent a substantially different picture which does not show up in this normalization. In order to capture this picture and facilitate the cross-country comparison, we provide a complementary indicator, I_{jt}, as indicated in (9).

less than unity indicates that country *j*'s exports are inherently more pollution-intensive than its imports in year *t*.

In terms of data, this study differs from those of Walter (1973) and Robison (1988) in that we use a newly available index, the Linear Acute Human Toxic Intensity (LAHTI) index,[11] developed by the Industrial Pollution Projection System (IPPS) of the World Bank in 1994,[12] to measure the embodied environmental factor services. The LAHTI index belongs to the family of pollution intensity indexes and it measures the amount of pounds of toxic chemical releases and transfers per US$1,000.

The highest LAHTI index is for fertilisers and pesticides (ISIC 3512) with 105.3 risk-weighted pounds of toxic chemical releases and transfers per US$1,000 of product shipped while the lowest LAHTI index is for soft drinks and carbonated water (ISIC 3134), with only 0.22 pounds per US$1,000. The LAHTI index generally confirms the intuitive belief that the most intensive sectors in terms of toxic waste per dollar of output are industrial chemicals, plastics, paper and metals. The middle-ranked sectors are associated with consumer products such as electrical appliances, textiles, and cleaning preparations, followed by the high shipment value (and consequently relatively low intensity) machine-tool industry, with the food and drink sectors filling the least-intensive rankings.

Data for exports and imports by ISIC sector for each country from 1970–1996 are calculated. This is done by making a concordance between ISIC and SITC codes. We have data for 18 APEC economies exports and imports for each ISIC four-digit sector in the last 26 years. These ISIC four-digit sectors match the sectors of the pollution intensity developed by World Bank IPPS project (1994).

If regional cooperation leads to migrations of 'dirty' industries, one would expect a significant fall in net exports of embodied environmental factor services and a significant increase of embodied environmental factor services imports for countries with more stringent environmental regulations.

IV. A Comparison of Approaches

In this section, we discuss the significance of our modification of the methodology comparing it with Walter (1973), using data for the Unit-

[11] Lee and Roland-Holst (1997) also use this index for a different sort of examination of the pollution content of Japan and India's trade.

[12] For a detailed discussion of the construction of this index, see Hettige et al. (1994).

ed States as an example. Recall that we make use of (6) in the calculation of the environmental factor content of trade. One interpretation of this approach is that the United States' environmental factor content of trade is simply the trade-share-weighted average of pollution content across ISIC four-digit sectors. Equation (6) is written again for convenience as follows:

$$V_{jt}^{T} = \sum_{i} \left(\frac{a_i^{US} X_{ijt}}{\sum_{i} X_{ijt}} \right) - \sum_{i} \left(\frac{a_i^{US} M_{ijt}}{\sum_{i} M_{ijt}} \right). \tag{6}$$

If the United States was shifting away from pollution-intensive goods exports to non-pollution-intensive goods exports, the export-share-weighted average of the pollution content would decrease. This formula can therefore be used to look at the changing trade pattern of embodied environmental factor services.

Walter (1973) makes use of the following approach

$$V_{jt}^{T} = \sum_{i} a_i^{US} X_{ijt} - \sum_{i} a_i^{US} M_{ijt} . \tag{10}$$

This is nothing but an explicit expression of (4). Instead of using trade share as the weight, Walter (1973) uses trade (exports or imports) value as the weight in (10).

If the assumptions that trade is balanced at all points of time and that there is no inflation hold (as in the Heckscher–Ohlin–Vanek (H–O–V) Theorem), there is no problem with using this approach. However, changes in export unit value and/or import unit value and, in particular, changes in macroeconomic balance would have different implications for trade in environmental factor services. Suppose national saving is less than investment and this transmits directly to a simultaneous increase in the current account deficit. For simplicity, this current account deficit leads to a ε per cent across-the-board increase in imports while exports remain unchanged. This produces a net export content of environmental factor services at time $t + 1$ as follows

$$V_{j,t+1}^{T} = \sum_{i} a_i^{US} X_{ij,t+1} - (1+\varepsilon) \sum_{i} a_i^{US} M_{ij,t+1} . \tag{11}$$

This will lead to an exaggeration of falls in the environmental factor content of net exports although there is no significant change in environmental regulation policy. If one makes use of (6), a ε per cent across-the-board increase in imports resulting from a macroeconomic imbal-

ance with exports remaining unchanged will not lead to any change in the environmental factor content of net exports. To express this more clearly, we have

$$V_{jt}^{T} = \sum_{i}\left(\frac{a_i^{US} X_{ijt}}{\sum_{i} X_{ijt}}\right) - \sum_{i}\left(\frac{a_i^{US}(1+\varepsilon) M_{ijt}}{\sum_{i}(1+\varepsilon) M_{ijt}}\right)$$
$$= \sum_{i}\left(\frac{a_i^{US} X_{ijt}}{\sum_{i} X_{ijt}}\right) - \sum_{i}\left(\frac{a_i^{US} M_{ijt}}{\sum_{i} M_{ijt}}\right). \tag{12}$$

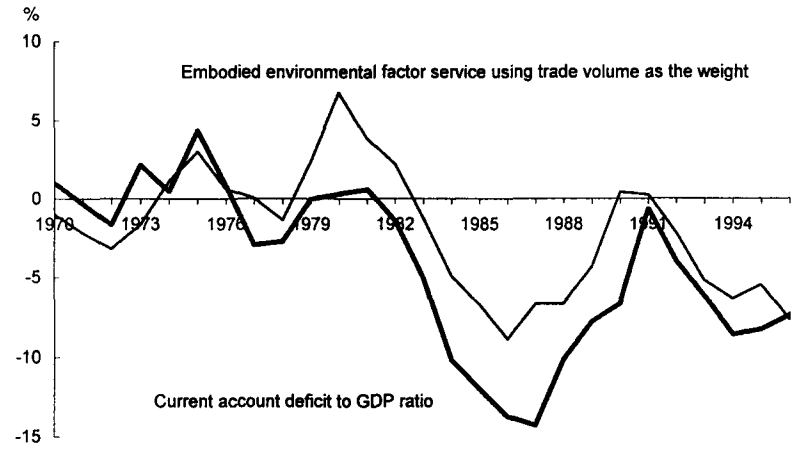
So V_{jt} remains unchanged.

Using the United States as an example, we first deflate US export and import values by the export unit value and import unit value indexes to remove any inflationary effects. Then we make use of (10) to calculate the embodied environmental content of trade from 1970 to 1996. The resulting volume of environmental factor services in 1970 is then normalized to unity. In order to see how macroeconomic imbalance affects the result, we also normalize the United States' current account deficit as a percentage of GDP so that it is also unity in 1970.

Figure 1 presents the changing pattern of these two indicators. The most striking feature is that the changing pattern of trade in embodied environmental factor services closely follows the current account imbalance. This is not surprising given the fact that, as reflected in (11), a change in the macroeconomic balance will lead to an exaggeration of falls in the environmental factor content of net exports. Unless the effects of macroeconomic imbalance in the United States in the 1970s and 1980s are taken into account, the resulting trend in the pattern of environmental factor services can be very misleading.

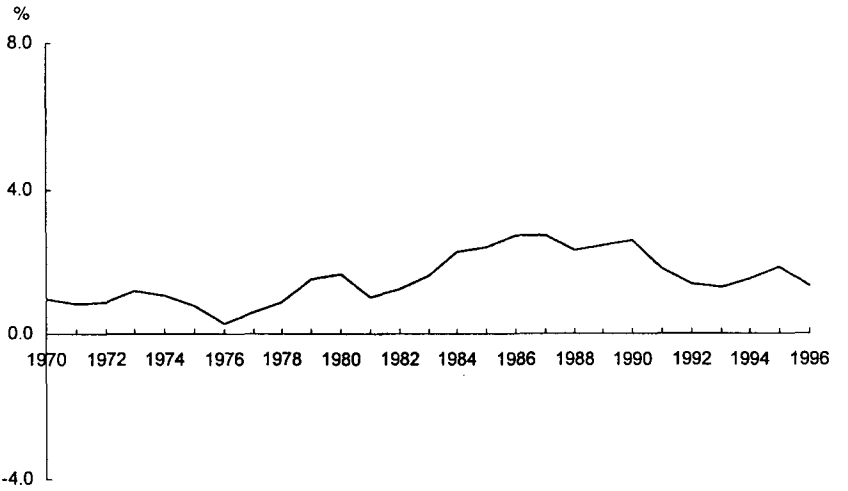
A macroeconomic imbalance will not lead to any changes in the environmental factor content of net exports if one applies (6) (see (12) for details). Figure 2 plots the changing pattern of environmental factor services from 1970 to 1996 after removing the inflationary effect and the macroeconomic imbalance effect. We can now compare it with what we observe using export (import) value as the weight. The significant difference is that there actually was a persistent trade pattern of embodied environmental factor services in the last 26 years in the United States.

Figure 1 – *United States: Current Account Imbalance and Trends of Embodied Environmental Factor Services Trade Using Trade Volume as the Weight*



Source: Authors' calculations. Data for exports and imports are from UNIDO. Data for export and import unit value, current account as a percentage of GDP are from *International Financial Statistics*, IMF.

Figure 2 – *United States: Trends of Embodied Environmental Factor Services Trade Using Trade Share as the Weight*



Source: Authors' calculations. See Figure 1 for data sources.

V. Do 'Dirty' Industries Migrate?

Table 1 presents trends in bilateral net exports of environmental factor services,[13] with a normalization performed in 1970, using equation (6). We divide the APEC region into 7 subregions, largely in terms of geographical consideration and partly in terms of stages of economic development. They are China, Japan, ASEAN (5), Mexico and Chile, North America, NIEs, and Oceania (see definitions in the note of Table 1).

Two distinct features emerge from this table. First, we observe that the sign remains unchanged in this period for the majority of countries. This indicates that there are no significant structural changes of the pollution content of trade among APEC economies. Countries that are net importers of embodied environmental factor services remained so throughout the period examined, as did countries who were net exporters of environmental factor services. Take the United States and Canada's net exports of environmental factor services to Mexico and Chile as an example. If net exports of embodied environmental factor services are normalized to unity for 1970, this index remains around 1.4 in the 1990s. If the difference of environmental stringency has significant effects on trade patterns, we would have observed a significant decline of net exports of embodied environmental factor services from North America to Mexico and Chile. This result indicates that no systematic structural changes occurred in patterns of the pollution content of trade despite the introduction of higher environmental regulations in the 1970s and 1980s in most developed countries and of the trade liberalization process in the APEC region. Of course, there are a few exceptions, for example, Oceania's net exports of embodied environmental factor services to NIEs, to Japan, and to ASEAN, where structural changes do occur.

The second feature from Table 1 is that bilateral trade in embodied environmental factor services between Japan and other East Asian economies do reveal a 'cascading' pattern (see Figure 3). Japan's net exports of embodied environmental factor services to NIEs, for example, drop substantially from the late 1970s to the early 1990s with net exports of embodied environmental factor services in the early 1990s accounting for only 0.1 of that in the early 1970s. NIEs' net exports

[13] It should be noted that the computation of the factor content of bilateral trade might only have limited predictive power in a world with many countries and many factors. However, in a region like APEC where intra-regional trade has increasingly been dominant and resource endowments across member economies have been very diversified, this empirical exercise may be able to serve the purpose especially when one's interest is on regional migration of 'dirty' industries as regional economic integration deepens. We thank one referee for pointing it out to us.

Table 1 – *APEC Economies: Trends in Bilateral Net Exports of Environmental Factor Services: 1970–1996 (five-year-average, 1970–1974 = 1)*

Reporter	Partner						
	China	Japan	ASEAN 5	Mexico & Chile	North America	NIEs	Oceania
China							
1970–74							
1975–79							
1980–84		–1.0	1.0	–1.0	–1.0	–1.0	1.0
1985–89		0.2	–0.6	–0.9	–0.7	–1.7	–0.4
1990–94		–0.6	–0.1	–1.5	–0.6	–3.7	–3.2
1995–96		–0.8	0.3	–1.0	–0.6	–4.7	–2.5
Japan							
1970–74			1.0	–1.0	–1.0	1.0	1.0
1975–79			0.9	–1.0	–1.5	0.9	–0.2
1980–84	1.0		0.2	–1.9	–2.1	0.3	–0.9
1985–89	–0.1		0.1	–2.4	–1.8	0.2	–1.2
1990–94	0.6		0.1	–1.8	–1.2	0.1	–1.1
1995–96	0.7		0.2	–1.4	–0.8	0.4	–1.5
ASEAN 5							
1970–74		–1.0		–1.0	–1.0	–1.0	
1975–79		–0.7		–5.4	–1.3	–1.1	–1.0
1980–84	–1.0	–0.1		–6.5	–1.2	–0.9	–1.7
1985–89	0.5	–0.2		–4.1	–1.1	–0.9	–3.0
1990–94	–0.3	–0.2		–3.2	–0.7	–1.0	–2.2
1995–96	–0.6	–0.3		–2.3	–0.7	–0.8	–0.8
Mexico & Chile							
1970–74		1.0	1.0		–1.0	1.0	1.0
1975–79		2.0	0.0		–0.9	1.1	1.7
1980–84	1.0	2.4	6.7		–0.8	3.2	1.0
1985–89	1.0	1.9	4.5		–1.6	2.1	1.2
1990–94	0.7	1.8	1.6		–1.0	1.7	0.7
1995–96	0.3	1.3	1.2		–1.3	1.6	0.6
North America							
1970–74		1.0	1.0	1.0		1.0	1.0
1975–79		1.5	1.0	0.6		1.1	–1.1
1980–84	1.0	2.2	1.0	0.6		1.5	–2.1
1985–89	0.7	2.0	1.1	1.3		2.0	–2.0
1990–94	0.7	1.3	0.7	1.1		1.6	–1.5
1995–96	0.6	0.9	0.8	1.4		2.0	–1.7
NIEs							
1970–74		–1.0	1.0		–1.0		1.0
1975–79		–0.9	1.0	–1.0	–1.3		1.7
1980–84	1.0	–0.3	0.6	–1.7	–1.6		1.2
1985–89	0.3	–0.2	0.5	–1.3	–1.8		–2.7
1990–94	1.1	–0.1	0.7	–0.8	–1.4		–3.5
1995–96	1.6	–0.3	0.7	–0.7	–1.6		–5.0

(Table continued on next page)

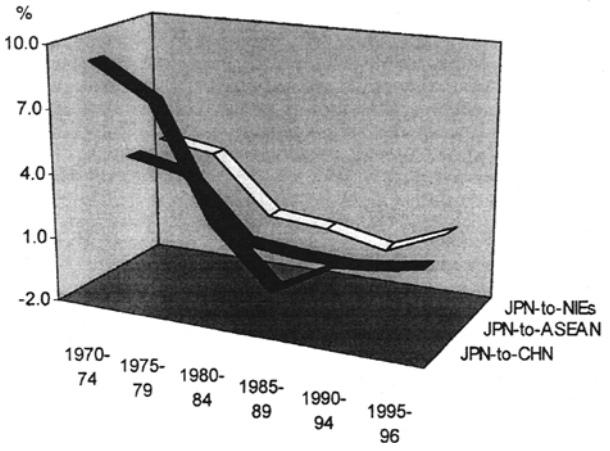
Table 1 – (*Continued*)

Reporter	Partner						
	China	Japan	ASEAN 5	Mexico & Chile	North America	NIEs	Oceania
Oceania							
1970–74		–1.0	–1.0	–1.0	–1.0	1.0	
1975–79		–0.7	1.3	–1.0	–1.5	–2.1	
1980–84	–1.0	–0.2	0.7	–0.8	–1.6	–3.3	
1985–89	–0.4	0.8	0.5	–0.7	–1.2	2.1	
1990–94	–0.7	0.7	3.6	–0.6	–1.0	4.3	
1995–96	–0.4	0.9	3.2	–0.7	–0.9	6.8	

Note: NIEs stands for 'Newly Industrialized Economies' and includes South Korea, Taiwan, Hong Kong, and Singapore. ASEAN (5) stands for 'Association of Southeast Asian Nations' and includes here Thailand, Malaysia, the Philippines, Indonesia, and Brunei. North America includes the United States and Canada. Oceania includes Australia, New Zealand, and Papua New Guinea. For China, the normalization is carried out in 1980–1984 when the country opens up.

Source: Authors' calculations based on United Nations COMTRADE database, United Nations Industrial Development Organization's industrial statistics available at the International Economic Databank, Australian National University, and World Bank's LAHTI pollution intensity data.

Figure 3 – *Japan's Net Exports of Embodied Environmental Factor Services to Other East Asian Economies: 1970–1996*



Note: Since the magnitude of this index itself is of no interest but its trend, this figure shows the exact number (the same changing patterns for the normalized numbers). The basic interest here is the trend of the changing patterns of pollution content of trade.

Source: See Table 1.

Table 2 – *APEC Economies: Patterns of Environmental Factor Content of Trade: 1970–1996 (import/export ratio)*

Reporter	Partner						
	China	Japan	ASEAN 5	Mexico & Chile	North America	NIEs	Oceania
China							
1970–74		1.9	0.7	11.9	1.0	1.4	0.9
1975–79		1.8	0.5	2.1	2.1	1.3	1.0
1980–84		1.2	0.5	2.7	3.0	1.1	0.8
1985–89		1.0	1.3	2.7	2.5	1.2	1.1
1990–94		1.2	1.0	3.7	2.3	1.4	1.8
1995–96		1.2	0.9	2.7	2.3	1.5	1.6
Japan							
1970–74	0.5		0.7	1.3	1.6	0.6	0.8
1975–79	0.5		0.7	1.4	2.0	0.7	1.1
1980–84	0.8		0.9	1.9	2.6	0.9	1.3
1985–89	1.0		1.0	2.4	2.6	0.9	1.4
1990–94	0.8		1.0	2.1	2.0	1.0	1.5
1995–96	0.8		0.9	1.9	1.6	0.8	1.7
ASEAN 5							
1970–74	1.6	1.5	1.1	1.4	1.8	1.6	1.0
1975–79	2.5	1.4	1.1	4.9	2.0	1.6	1.1
1980–84	2.5	1.1	1.0	10.8	2.1	1.5	1.2
1985–89	0.8	1.1	1.0	4.5	2.0	1.5	1.3
1990–94	1.2	1.1	1.0	3.3	1.8	1.5	1.3
1995–96	1.4	1.2	1.0	2.6	1.8	1.5	1.1
Mexico & Chile							
1970–74	0.1	0.7	0.7	0.9	1.3	0.8	0.3
1975–79	0.4	0.5	1.0	1.1	1.2	0.6	0.3
1980–84	0.4	0.4	0.1	0.9	1.3	0.3	0.4
1985–89	0.4	0.5	0.2	1.1	1.6	0.4	0.4
1990–94	0.5	0.4	0.5	1.1	1.4	0.5	0.5
1995–96	0.7	0.6	0.6	1.1	1.6	0.5	0.6
North America							
1970–74	1.0	0.7	0.6	0.8	1.0	0.7	0.7
1975–79	0.5	0.5	0.6	0.9	1.0	0.7	1.3
1980–84	0.3	0.4	0.5	0.8	1.0	0.7	1.6
1985–89	0.4	0.4	0.5	0.7	1.0	0.6	1.6
1990–94	0.5	0.5	0.6	0.7	1.0	0.6	1.4
1995–96	0.5	0.6	0.6	0.6	1.0	0.5	1.4
NIEs							
1970–74	0.7	1.7	0.6	1.0	1.5	1.1	0.9
1975–79	0.9	1.5	0.6	2.5	1.6	1.1	0.9
1980–84	0.8	1.2	0.8	3.8	1.7	1.0	0.9
1985–89	0.9	1.1	0.8	3.3	1.9	1.0	1.2
1990–94	0.8	1.1	0.7	2.5	1.8	1.0	1.3
1995–96	0.7	1.2	0.7	2.4	2.1	1.0	1.4

(Table continued on next page)

Table 2 – (*Continued*)

Reporter	Partner						
	China	Japan	ASEAN 5	Mexico & Chile	North America	NIEs	Oceania
Oceania							
1970–74	1.2	1.6	1.0	4.1	1.8	0.9	1.0
1975–79	1.0	1.4	1.0	3.8	2.9	1.1	1.2
1980–84	1.3	1.1	1.0	4.0	3.3	1.2	1.3
1985–89	1.1	0.7	1.0	2.8	2.2	0.9	1.2
1990–94	1.2	0.7	0.9	2.9	1.9	0.8	1.2
1995–96	1.1	0.6	0.9	3.1	1.7	0.7	1.1

Note: See note in Table 1 for country group definition.

Source: See Table 1.

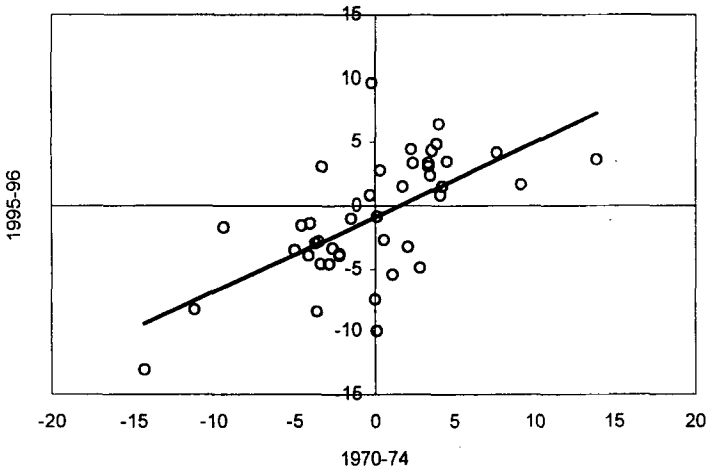
of embodied environmental factor services to ASEAN also reveals a similar pattern with net exports of embodied environmental factor services in the early 1995–1996 accounting for only 0.2 of that in the early 1970s.

However, bilateral trade in embodied environmental factor services between North America and Mexico and Chile does not indicate significant changes. North America's net exports of embodied environmental factor services to Mexico and Chile remains positive with net exports of embodied environmental factor services in the early 1990s being 1.4 times of that in the early 1970s. Despite the introduction of NAFTA trade agreement in the early 1990s, 'dirty' industries are not observed indirectly to migrate from countries with higher environmental regulations (the United States and Canada) to countries with relatively lower environmental regulations (Mexico and Chile).

Bilateral trade between Oceania and NIEs, Oceania and ASEAN economies, do exhibit substantial structural changes. Oceania's net exports of embodied environmental factor services to both NIEs and ASEAN economies increase dramatically in the last decade.

Similar patterns can be found in Table 2, where the ratios of pollution content of imports to exports are calculated using (9). For example, North America's trade with Mexico and Chile has a pollution content of imports to exports ratio of 0.80 in 1970–1974, indicating that North America exported more environmental factor services than it imported from Mexico and Chile. This ratio decreases gradually and is 0.6 in 1995–1996. Japan also exports more embodied environmental factor

Figure 4 – *Correlations of Bilateral Net Exports of Embodied Environmental Factor Services among APEC Economies: 1970–1974 vs 1995–1996*



Source: See Table 1.

services than it imports from NIEs and ASEAN, with the ratio increasing throughout the period studied.

When we plot net export performance of embodied environmental factor services in 1970–1974 against that in 1995–1996 for each country selected, we obtain the picture shown in Figure 4. The underlying data are given in Table 1. As this figure reveals, most of the data points are bunched in the first (northeast) and the third (southwest) quadrants, suggesting very strongly that there is a positive correlation between the net export performance of embodied environmental factor services in 1970–1974 and that in 1995–1996. This indicates that countries that are net importers of embodied environmental factor services remained so throughout the period examined, as did countries who were net exporters of embodied environmental factor services (in the bilateral trade context). A simple correlation test indicates there is a positive correlation between the performance in the initial year and that of the end year (see Figure 4).

VI. Conclusion

In this paper, the environment has been treated as a factor of production. On the basis of this perspective, we address the issue of regional

cooperation and the environment by investigating the changing patterns of trade in embodied environmental factor services across more than 70 ISIC sectors for 18 APEC economies in the period 1970–1996. More specifically, we address the following question: Do 'dirty industries' migrate along with the deepening of regional cooperation?

There are few studies of the environmental factor content of trade in the literature. This study differs from those of Walter (1973) and Robison (1988) in terms of both data and methodology. A newly available data set for a pollution intensity index constructed by the IPPS project of the World Bank in 1994 is used in this study. Instead of using trade value to calculate net exports of environmental factor services, we use the trade-share-weighted average to impute the net export content of environmental factor services. The significance of this modification is that it removes biases from both the effects of inflation and macroeconomic imbalance. Thanks to the newly available highly disaggregated data, we are able to investigate this issue in a bilateral trade context.

Our results indicate that the bilateral net export content of environmental factor services for the majority of the countries in the study does not experience systematic structural change in the last 26 years, despite the diversity of environmental regulations across this region and the deepening of regional cooperation in the APEC economies.[14] We do observe a 'cascading' pattern between Japan, NIEs, and ASEAN in which Japan's net exports of embodied environmental factor services to NIEs and ASEAN economies experiencing a significant decline in the 1980s. However, we do not observe a similar pattern in the trade between North America (the United States and Canada) and Mexico and Chile. The results should be interpreted with caution since the application of US sectoral pollution intensity data to other countries may lead to over- or underestimation of the pollution content of trade.

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[14] For an empirical test on the determinants of trade pattern of environmentally sensitive goods, refer to Xu (2000).

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Abstract: Regional Cooperation and the Environment: Do "Dirty" Industries Migrate? – This article develops an alternative method to investigate trade in embodied environmental factor services (EEFS) and applies it to bilateral trade between APEC economies. The issue of regional cooperation and the environment is addressed by investigating trade in EEFS between APEC economies in the last three decades. We observe a 'cascading' pattern in net exports of EEFS between East Asian economies. However, we do not observe a similar pattern in the trade between North American economies. The results should be interpreted with caution since the application of US sectoral pollution intensity data to other countries may lead to biased estimation of trade in EEFS.
JEL No. F02, F20, Q28

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Zusammenfassung: Regionale Kooperation und Umwelt: Wandern „schmutzige" Industriezweige? – Dieser Artikel entwickelt eine alternative Methode zur Untersuchung des Handels mit den Dienstleistungen, die die Umwelt als Produktionsfaktor bei der Herstellung von Gütern bereitstellt (EEFS, embodied environmental factor services), und wendet diese auf den bilateralen Handel zwischen den APEC-Ländern an. Der Zusammenhang zwischen einer sich verstärkenden regionalen Kooperation und der Umweltnutzung in den entsprechenden Ländern wird untersucht, indem der Handel mit EEFS zwischen den APEC-Ländern während der letzten drei Jahrzehnte analysiert wird. Es lässt sich ein kaskadenähnliches Muster in den Netto-Exporten von EEFS im Handel zwischen den ostasiatischen Volkswirtschaften feststellen. Beim EEFS-Handel zwischen nordamerikanischen Volkswirtschaften kann jedoch kein ähnliches Muster entdeckt werden. Bei der Interpretation der Ergebnisse ist allerdings Vorsicht geboten, da die Anwendung von US-amerikanischen Daten der sektoralen Umweltverschmutzungsintensität auf andere Länder die Schätzung des Handels mit EEFS verzerren kann.