A Structural Decomposition Analysis of Pollution Terms of Trade Using WIOD

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Abstract

Antweiler's (1996) Pollution Terms of Trade (PTT) index uses the ratio of the export pollution intensity to the import pollution intensity to indicate the relative cleanness of a country's exports versus its imports. If the PTT is greater than one, a country's exports are, on average, dirtier than its imports. The PTT is determined by three factors: the production technology, the final demands and the emission intensities. These factors change over time, so that also the PTT changes. In this study, we decompose the change of PTT into the three factors using an MRIO model with annual WIOD data in current and constant prices. The dataset covers the period from 1995 to 2006. The structural decomposition analyses attempts to answer the following questions. The change in which factor (i.e. production technology, final demands or emission intensities) contributes the most to the changes in each of the countries' emissions trade balance (imbalance) in general and to the changes in the PTT? Do changes in demand (or technology) at home have the same effect on the PTT as changes abroad? Answering these questions is relevant for environmental policies.

Keywords: Pollution Terms of Trade, World Input-Output Database, multi-country input-output model

1. Introduction

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2. Decomposition Methods

The matrix of intermediate deliveries is given by

$$\mathbf{Z} = \begin{bmatrix} \mathbf{Z}^{11} & \mathbf{Z}^{12} & \cdots & \mathbf{Z}^{1,N-1} & \mathbf{Z}^{1N} \\ \mathbf{Z}^{21} & \mathbf{Z}^{22} & \cdots & \mathbf{Z}^{2,N-1} & \mathbf{Z}^{2N} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \mathbf{Z}^{N-1,1} & \mathbf{Z}^{N-1,2} & \cdots & \mathbf{Z}^{N-1,N-1} & \mathbf{Z}^{N-1,N} \\ \mathbf{Z}^{N,1} & \mathbf{Z}^{N,2} & \cdots & \mathbf{Z}^{N,N-1} & \mathbf{Z}^{N,N} \end{bmatrix}.$$

The input coefficients are obtained as $a_{ij}^{rs} = z_{ij}^{rs} / x_j^s$, where x_j^s gives the gross domestic output of sector *j* in region *s*. The input matrix **A** has the same structure as the matrix **Z**, replacing $\mathbf{Z}^{rs}$ by $\mathbf{A}^{rs}$.

In general, if there are *N* regions in the world each has *n* sectors, we could define an $N \times N$ bilateral emission trade matrix by **P**, which is obtained by,

$$\mathbf{P} = \mathbf{W}'(\mathbf{I} - \mathbf{A})^{-1}\mathbf{F} = \mathbf{V} \times \mathbf{F},$$

where **W** is the $Nn \times N$ matrix of *direct* CO_2 *emission factor*, with

$\mathbf{w}^{\mathrm{N}} = \Sigma_{\mathrm{s}=1}^{\mathrm{N}-1}\mathbf{w}^{\mathrm{s}}/(\mathrm{N}-1)$,

$$\mathbf{W} = \begin{bmatrix} \mathbf{w}^1 & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \mathbf{w}^2 & & \vdots \\ \vdots & & \ddots & \mathbf{0} \\ \mathbf{0} & \cdots & \mathbf{0} & \mathbf{w}^N \end{bmatrix},$$

F is the final demand matrix,

$$\mathbf{F} = \begin{bmatrix} \mathbf{f}^{11} & \mathbf{f}^{12} & \cdots & \mathbf{f}^{1,N-1} & \mathbf{f}^{1N} \\ \mathbf{f}^{21} & \mathbf{f}^{22} & \cdots & \mathbf{f}^{2,N-1} & \mathbf{f}^{2N} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \mathbf{f}^{N-1,1} & \mathbf{f}^{N-1,2} & \cdots & \mathbf{f}^{N-1,N-1} & \mathbf{f}^{N-1,N} \\ \mathbf{f}^{N1} & \mathbf{f}^{N2} & \cdots & \mathbf{f}^{N,N-1} & \mathbf{f}^{NN} \end{bmatrix}$$

and **V** is the $N \times Nn$ matrix of the abbreviation for the products of $\mathbf{W}'$ and $(\mathbf{I}-\mathbf{A})^{-1}$, with elements of $1 \times n$ vector $(v^{rs})'$,

$$\mathbf{V} = \begin{bmatrix} (\mathbf{v}^{11})' & \cdots & (\mathbf{v}^{1N})' \\ \vdots & \ddots & \vdots \\ (\mathbf{v}^{N1})' & \cdots & (\mathbf{v}^{NN})' \end{bmatrix}.$$

Assume that focal region is region *r*, and all the other regions are non-focal regions. The pollution embodied in exports (PEE) for the focal region *r* is,

$$\mathbf{PEE}^r = \underbrace{[\sum_{k=1}^{N}(\mathbf{v}^{kr})'](\sum_{s\neq r}^{N}\mathbf{f}^{rs})}_{A_N} + \underbrace{\sum_{s\neq r}^{N}[(\mathbf{v}^{rs})'(\sum_{k=1}^{N}\mathbf{f}^{sk})]}_{B_N},$$

where part A_N represents the emission generated all over the world in order to produce exports of region *r* for the final users in all the other regions, and part B_N represents the emissions generated in region *r* for exports of intermediate deliveries from region *r* to all the other regions in order to produce goods and services for the final users all over the world.

The pollution embodied in imports is,

$$\mathbf{PEM}^r = \underbrace{\sum_{s\neq r}^{N}[\sum_{k=1}^{N}(\mathbf{v}^{ks})']\mathbf{f}^{sr}}_{C_N} + \underbrace{[\sum_{s\neq r}^{N}(\mathbf{v}^{sr})'](\sum_{k=1}^{N}\mathbf{f}^{rk})}_{D_N},$$

In conclusion, the pollution terms of trade (PTT) can be wrote as,

$$\mathbf{PTT}^r$$

$$= \frac{\boldsymbol{\iota}'_N \mathbf{W}'(\mathbf{I}-\mathbf{A})^{-1}\mathbf{E}^r(\mathbf{E}^r)'(\mathbf{F}-BlockDiagnal(\mathbf{F}))\boldsymbol{\iota}_N + (\mathbf{e}^r)'[\mathbf{W}'(\mathbf{I}-\mathbf{A})^{-1} - BlockDiagnal(\mathbf{W}'(\mathbf{I}-\mathbf{A})^{-1})]\mathbf{F}\,\boldsymbol{\iota}_N}{\boldsymbol{\iota}'_N \mathbf{W}'(\mathbf{I}-\mathbf{A})^{-1}(\mathbf{F}-BlockDiagnal(\mathbf{F}))\mathbf{e}^r + \boldsymbol{\iota}'_N[\mathbf{W}'(\mathbf{I}-\mathbf{A})^{-1} - BlockDiagnal(\mathbf{W}'(\mathbf{I}-\mathbf{A})^{-1})]\mathbf{E}^r(\mathbf{E}^r)'\mathbf{F}\,\boldsymbol{\iota}_N}$$

$$= \frac{f(\mathbf{W},\mathbf{A},\mathbf{F})}{g(\mathbf{W},\mathbf{A},\mathbf{F})}.$$

We define $\boldsymbol{\iota}_N = \begin{bmatrix}1\\ \vdots \\ 1\end{bmatrix}_{N\times 1}$, $\mathbf{e}^r = \begin{bmatrix}0^1\\ \vdots \\ 0^{r-1}\\ 1\\ 0^{r+1}\\ \vdots \\ 0^N\end{bmatrix}_{N\times 1}$ and $\mathbf{E}^r = \begin{bmatrix}\mathbf{0}^1\\ \vdots \\ \mathbf{0}^{r-1}\\ \mathbf{I}_n\\ \mathbf{0}^{r+1}\\ \vdots \\ \mathbf{0}^N\end{bmatrix}_{Nn\times n}$, where $\mathbf{I}_n$ is an $n\times n$ identity matrix and $\mathbf{0}^s$, $s\neq r$, are $n\times n$ zero matrices, so the transpose of them are $\boldsymbol{\iota}'_N = \begin{bmatrix}1 & \cdots & 1\end{bmatrix}_{\times N}$, $(\mathbf{e}^r)' = \begin{bmatrix}0^1 & \cdots & 0^{r-1} & 1 & 0^{r+1} & \cdots & 0^N\end{bmatrix}_{\times N}$ and $(\mathbf{E}^r)' = \begin{bmatrix}\mathbf{0}^1 & \cdots & \mathbf{0}^{r-1} & \mathbf{I}_n & \mathbf{0}^{r+1} & \cdots & \mathbf{0}^N\end{bmatrix}_{\times Nn}$.

We could also define two new matrices related to **V** and **F**:

$$BlockDiagnal(\mathbf{V}) = \begin{bmatrix}(\mathbf{v}^{11})' & \cdots & \mathbf{0}'\\ \vdots & \ddots & \vdots\\ \mathbf{0}' & \cdots & (\mathbf{v}^{NN})'\end{bmatrix}_{N\times Nn},$$

$$BlockDiagnal(\mathbf{F}) = \begin{bmatrix}\mathbf{f}^{11} & \cdots & \mathbf{0}\\ \vdots & \ddots & \vdots\\ \mathbf{0} & \cdots & \mathbf{f}^{NN}\end{bmatrix}_{Nn\times N}.$$

Matrix **A** could be disaggregated into a part that is associated with technology within each sector (**H**) and that part associated with trade in each sector (**T**) (i.e. the share of input of good *i* by sector *j* in country *r* that originates in country *s*). Matrix **F**, the final demand, could be further disaggregated into a part that reflects overall level of final demand (**q**) and a part that captures trade of final demand (**d**).

We define the technology

$$\mathbf{H}^r = \sum_{s=1}^{N} \mathbf{A}^{sr}$$

and the trade matrix $\mathbf{T}^{sr}$ such that elements in it,

$$t_{ij}^{sr} = a_{ij}^{sr} / h_{ij}^r$$

It is easy to prove that

$$a_{ij}^{sr} = t_{ij}^{sr} \times h_{ij}^r$$

or

$$A^{sr} = T^{sr} \otimes H^{r}$$

where $\otimes$ means multiply element by element.

Note that $\sum_{s=1}^{N} t_{ij}^{sr} = 1$, for $\forall r, \forall i, j$, and $\sum_{s=1}^{N} \mathbf{T}^{sr} = \begin{bmatrix} 1 & \cdots & 1 \\ \vdots & \ddots & \vdots \\ 1 & \cdots & 1 \end{bmatrix}$. Also note that $\mathbf{T}^{rr}$ gives the share of input of good *i* by sector *j* in country *r* that originates in country *r*.

Therefore, the matrix **A** could be rewritten as,

$$\mathbf{A} = \begin{bmatrix} \mathbf{T}^{11} \otimes \mathbf{H}^{1} & \cdots & \mathbf{T}^{1N} \otimes \mathbf{H}^{N} \\ \vdots & \ddots & \vdots \\ \mathbf{T}^{N1} \otimes \mathbf{H}^{1} & \cdots & \mathbf{T}^{NN} \otimes \mathbf{H}^{N} \end{bmatrix}.$$

In a similar way, we can disaggregate the matrix **F**.

Define the composition vector

$$\mathbf{q}^{r} = \sum_{s=1}^{N} \mathbf{f}^{sr}.$$

We then define the overall level of final demand,

$$d_{j}^{sr} = f_{j}^{sr} / q_{j}^{r}.$$

We could have

$$\mathbf{f}^{sr} = \mathbf{d}^{sr} \otimes \mathbf{q}^{r}$$

and

$$\mathbf{F} = \begin{bmatrix} \mathbf{d}^{11} \otimes \mathbf{q}^{1} & \cdots & \mathbf{d}^{1N} \otimes \mathbf{q}^{N} \\ \vdots & \ddots & \vdots \\ \mathbf{d}^{N1} \otimes \mathbf{q}^{1} & \cdots & \mathbf{d}^{NN} \otimes \mathbf{q}^{N} \end{bmatrix}$$

We make distinguish between the home and abroad changes in technology, product mix, overall final demand and the composition of final demand. So we further define

$$\begin{aligned} \mathbf{T} &= \{\mathbf{T}^{(r)}, \ \mathbf{T}^{(-r)}\} \\ \mathbf{H} &= \{\mathbf{H}^{(r)}, \ \mathbf{H}^{(-r)}\} \\ \mathbf{d} &= \{\mathbf{d}^{(r)}, \ \mathbf{d}^{(-r)}\} \\ \mathbf{q} &= \{\mathbf{q}^{(r)}, \ \mathbf{q}^{(-r)}\} \end{aligned}, \text{ for } \forall r = 1,...,N,$$

where $\mathbf{X}^{(r)}$ denotes the elements related to production and consumption needs of region *r*, and $\mathbf{X}^{(-r)}$ denotes the elements unrelated to it. For example, $\mathbf{T}^{(r)} = \{\mathbf{T}^{kr}\}, \ k = 1,...,N$, and $\mathbf{T}^{(-r)} = \{\mathbf{T}^{ks}\}, \ k = 1,...,N \ \ and \ \ s \neq r$. $\mathbf{H}^{(r)} = \{\mathbf{H}^{r}\}$ and $\mathbf{H}^{(-r)} = \{\mathbf{H}^{s}\}, \ s \neq r$.

Now we can rewrite the PTT function as,

$$\mathbf{PTT}^r = \frac{f^r(\mathbf{W},\mathbf{T}^{(r)},\mathbf{T}^{(-r)},\mathbf{H}^{(r)},\mathbf{H}^{(-r)},\mathbf{d}^{(r)},\mathbf{d}^{(-r)},\mathbf{q}^{(r)},\mathbf{q}^{(-r)})}{g^r(\mathbf{W},\mathbf{T}^{(r)},\mathbf{T}^{(-r)},\mathbf{H}^{(r)},\mathbf{H}^{(-r)},\mathbf{d}^{(r)},\mathbf{d}^{(-r)},\mathbf{q}^{(r)},\mathbf{q}^{(-r)})}$$

Now, the two polar decompositions for region *r* is defined as polar1 and polar2.

$$\Delta\mathbf{PTT}^r = \sqrt{polar1^r \times polar2^r}$$

3.1 SDA Results of Pollution Embodied in Exports and Imports

Before we discuss how much each factor contributes to changes of Pollution Embodied in Exports (PEE) and Imports (PEM), we first take a look at changes of PEE and PEM. Ratios of PEE (PEM) in 2009 to PEE (PEM) in 1995 are presented in Figure 1, Table 1 and Table 2 in the Appendix.

PEE is increased in 32 countries and decreased in 8 countries. If PEE is increased from 1995 to 2009, the PEE ratio is larger than 1. There are 25 countries have PEE ratios between 1 and 2, 9 of which have PEE ratios higher than 1.5 (increased by more than 50%). In 7 countries, PEE ratios are higher than 2 (increased by more than 100%). Among them, Turkey, Greece and China's PEE ratios are even higher than 3 (increased by more than 200%). For the 8 PEE decreasing countries, 4 countries' PEE only changed slightly (by less than 4%) and 3 countries' PEE changed by around 10 to 20 percent. Only in Romania, PEE decreased dramatically by 41% from 40052 ton to 23631 ton.

All the countries' PEM are increased. In 26 countries, changes in PEM are less than 100% (PEM ratios are between 1 and 2). 14 of them have PEM ratios increased by less than 50% (PEM ratios < 1.5) and 12 of them have PEM increased by higher than 50% (PEM ratios >1.5). 12 countries' PEE increased by more than 100% but lower than 200% (2 < PEM ratios <3). India and China have the highest increase in PEM, with the PEM ratios 4.12 (from 53547 ton to 220614 ton) and 7.03 (from 107568 ton to 756203 ton), respectively.

In sum, Figure 1 indicates the change of PEE (PEM) from 1995 to 2009 is considerable in many countries. About half of the countries have their PEE (PEM) increased or decreased by more than 40%. In addition, in most countries, changes in PEM are larger than changes in PEE. With these observations, two general questions might come up: (1) what cause large changes of PEE and PEM? (2) why PEM increase more than PEE? The results of decomposition of PEE and PEM into three factors, emission intensity, production technology and final demand, are presented in Figure 2 and Figure 3, respectively. In these two figures, the blue line indicates ratios of PEE (PEM) in 2009 to that in 1995. The red line indicates effect of emission intensity to the changes of PEE (PEM), which is estimated by the SDA described in the previous section. The green line and purple line illustrate the estimated effects of production technology and final demand, respectively. For example, in Australia, PEE in 2009 to PEE in 1995 is 1.33, or a 33% increase from 1995 to 2009. If only change emission intensity from 1995 to 2009, the PEE ratio in Australia will decrease to 0.98. The effect of production technology is similar: a decrease of PEE ratio to 0.91. However, the final demand effect is positive, which makes PEE ratio increase to 1.50. The combined effect of three factors equals to the overall PEE ratio 1.33 ($1.33 \approx 0.98 \times 0.91 \times 1.50$).

Emission Intensity (W matrix)

Changes in emission intensity lowers both PEE and PEM in almost all the countries, except Indonesia, whose change in emission intensity increases PEE. The improvement in efficiency is considerable. Among the 8 countries whose PEE ratios are smaller than 1, 3 of them (Bulgaria, France and Netherlands) are caused by the dominance of emission intensity effects[1]. The decrease of PEE in the other 5 countries (Canada, Estonia, United Kingdom, Italy, Romania) are brought by both emission intensity and production technology effects.

In Figure 4, the effects of emission intensity on both PEE and PEM are illustrated. It shows the emission intensity effect on PEM is less vitiate than that on PEE. The red dots (ratios of PEM under emission intensity effects) range from 0.6 to 0.8. However, the blue dots (ratios of PEE under emission intensity effects) range from 0.4 to 1.07. The effects of emission intensity are not always larger or smaller on PEE than on PEM. From Figure 4, the chance is about half to half. We can observe from the Figure 4 that countries with higher PEE ratios tend to have lower PEM ratios. Why some countries have larger effects on PEE (PEM) than PEM (PEE), and why effects of emission coefficients on PEE and PEM are negatively correlated? These questions can be interesting for further investigation.

Production Technology (A matrix)

Changes in production technology make PEM higher. The effects on PEE are positive (PEE ratios higher than 1) in 26 countries and negative (PEE ratios lower than 1) in 14 countries. The comparison of production technology effects on PEE and PEM is presented in Figure 5. The PEE ratios after and before production technology change range from 0.62 to 2.68, and the PEM ratios range from 1.02 to 1.85. There's no clear relationship between effects on PEE and PEM. China has the highest PEE (2.68) and PEM (1.85) ratios.

We decompose the production technology effect into two categories: a part associated with technology within each sector (H) and a part associated with trade in each sector (T). The effects of above subcategories on PEE and PEM are shown in Figure 6 and Figure 7. In both figures, the red dots are almost always above 1, while the blue dots are occasionally below 1. Therefore, both H and T factors contribute to the increase of PEM. The decrease of PEM in 14 countries, only 4 are mainly brought by the dominance of trade (T) effect. In the rest 10 countries, both H and T effects cause the decrease of PEE. In general, we find H and T effects are usually in the same direction on both PEE and PEM.

We can further decompose the production technology effect into four subcategories as mentioned in section 2: a part associated with domestic technology within each sector (H^r), a part associated with foreign technology within each sector (H^{-r}), a part associated with trade for domestic production (T^r), and a part associated with trade for foreign production (T^{-r}). The results are presented in Table 1 and Table 2. With regard to T^r, PEE ratios are around 0.9 to 1, but the PEM ratios in most countries are larger than 1 and half of them are larger than 1.10. With regard to T^{-r}, PEM ratios are around 1.03, but PEE ratios range from 0.79 to 2.59 and in 20 countries PEE ratios are larger than 1.10. The effects of H^r on PEM are quite similar to the effects of T^r. However, changes in H^r makes PEE ratios further away from 1, which range from 0.61 to 1.42, and half of them are smaller than 1. Changes brought by H^{-r} are quite small for both PEE and PEM with ratios mostly between 0.90 to 1.10.

[1] Emission intensity makes PEE ratios smaller than 1, but the other two factors, production technology and final demand, make PEE ratios larger than 1.

To sum up, both H and T factors affect PEE and PEM. The increase of PEM under production technology effect are mainly brought by the part associated with domestic technology (H^r) and the part associated with trade for domestic production (T^r). The effects on PEE are mainly caused by the part associated with domestic technology (H^r) and the part associated with trade for foreign production (T^{-r}).

Final Demand (F matrix)

Changes in final demand makes both PEE and PEM higher. From Figure 2 and Figure 3, we can observe that changes in PEE and PEM are dominated by the final demand effect in most countries. In Figure 8, we present the effects of final demand on PEE and PEM. The two lines are both above 1 and close to each other. In most countries both PEE and PEM ratios fall between 1 and 2. In Ireland, Greece, Turkey, Slovak, Poland, India and China, the PEE and PEM ratios are both larger than 2.

We decompose the production technology effect into two categories: a part reflects overall level of final demand (q) and a part reflects trade of final demand (d). The effects of above subcategories on PEE and PEM are shown in Figure 9 and Figure 10. The effects of overall level of final demand are positive on both PEE and PEM, except PEM of Japan. Ratios of PEE after and before changes in q are around 1.5, ratios of PEM range from 0.9 (Japan) to 3.54 (China).

We further decompose the production technology effect into four subcategories: a part reflects overall level of domestic final demand (q^r), a part reflects overall level of foreign final demand (q^{-r}), a part reflects trade of final demand for domestic consumption (d^r), and a part reflects trade of final demand for foreign consumption (d^{-r}). The results are presented in Table 1 and Table 2. For changes of d^r, PEE ratios equal to 1 in almost all the countries, while PEM ratios range from 0.93 to 1.35. However, changes in d^{-r} makes PEE increase or decrease a lot in many countries. PEE ratios range from 0.85 to 2.24, with half of the countries higher than 1.10. PEM ratios close to 1 in most of the countries, but in Czech Republic, Slovak Republic, Poland and China the PEM ratios are higher than 1.2. Similar to d^r, changes in q^r brings almost no change in PEE, while PEM ratios range from 0.87 to 3.34. In all the countries, except Japan and Germany, PEM ratios are higher than 1.10, and in 31 countries, higher than 1.20. With regard to changes in q^{-r}, PEE increase dramatically and PEM has no big changes. The PEE ratios range from 1.29 to 1.77.

To sum up, the increase of PEE under final demand effect is mainly brought by the part reflects overall level of foreign final demand (q^{-r}). The increase of PEM is mainly brought by the part reflects overall level of domestic final demand (q^r).

3.2 SDA Results of Pollution Terms of Trade

As shown in Figure 11, 29 out of 40 countries' PTT ratios are lower than 1. This indicates around 3/4 of countries' PEM ratios are higher than PEE ratios. Within these 29 countries, 8 countries' PEE are decreased and PEM are increased, while 11 countries' PEE increase in a smaller percentage than PEM. In the rest 11 countries, whose PTT ratios are higher than 1, their PEE are increased in a larger percentage than PEM. We ordered the PTT ratios in a asending order from left to right in Figure 11. It is interesting to find that on the most left hand side of Figure 11, there are many emerging markets, such as China, India, Russia,

Romania, Slovak Republic and Poland. To the right of these countries are some developed countries, such as US, Canada, Australia, Netherlands, France and UK. In the most right hand side are Denmark, Greece and Taiwan. The results of PTT ratios are presented in Table 3.

Emission Intensity (W matrix)

The effects of emission intensity on PTT are in two directions. The improvement in efficiency lowers both PEE and PEM, so the effect on PTT depends on relative the improvement. As we can see from Figure 4 and Figure 11, countries with high PEE ratios tend to have low PEM ratios. PTT ratios range from 0.51 to 1.53 under the effect of emission intensity. 23 countries' PTT ratios are larger than 1, and 15 countries' PTT ratios are larger than 1.10.

Production Technology (A matrix)

The effects of production technology cause 32 out of 40 countries' PTT ratios smaller than 1. Changes in production technology make PEM ratios increase in all the countries, and PEE ratios decrease in 14 countries. In 18 countries, the positive effect on PEE is smaller than that on PEM, while in 8 countries, the positive effect on PEE is larger than that on PEM.

21 out of 32 countries with negative production technology effects on PTT have their PTT ratios lower than 1 under both technology within each sector (H) and trade in each sector (T) effects. The detailed results can be found in Table 4. Only two countries, Taiwan and Cyprus, have their PTT ratios larger than 1 under both effects. Among the remaining 18 countries, 9 of them are dominated by the positive T effect and 9 of them are dominated by the positive H effect. With further decomposition, we find PTT ratios are almost lower than 1 under T^r and H^r effects, and PTT ratios are higher than 1 in around half number of countries under T^{-r} and H^{-r} effects. The effects of H^{-r} is smaller than T^{-r}.[2]

Final Demand (F matrix)

The effects of final demand on PTT are quite similar as production technology. 25 out of 40 countries' PTT ratios are smaller than 1. These countries' PTT ratios are also smaller than 1 under production technology effect, except China. Among the 8 countries, whose PTT ratios are larger than 1 under final demand effect and PTT ratios are smaller than 1 under production technology effect, 4 have the overall PTT ratios lower than 1.

Except China, most of countries with negative effect of final demand on PTT have PTT ratios smaller than 1 under trade of final demand (d) effect and PTT ratios around 1 under level of final demand (q) effect. The detailed results can be find in Table 4. With further decomposition, PTT ratios under d^r and q^r effects are almost smaller than 1 and PTT ratios under d^{-r} and q^{-r} effects are larger than 1. The q^r and q^{-r} effects are larger than d^r and d^{-r} effects.

To sum up, the overall effects of efficiency, production technology and final demand changes on PTT are negative (PTT ratios smaller than 1) in 3/4 countries, because production technology and final demand make PEM increase more than PEE in most countries (except the 8 countries where PEE are decreased). The relative effects of each factor on PEE and PEM are different. A summary of these effects are presented in Table 5, where "+" and "-"

[2] PTT ratios are closer to 1 under H^{-r} effects than under T^{-r} effects.

indicate “increase” and “decrease”, and number of countries are written before signs. The subcategories of production technology and final demand do not always work in the same direction. For production technology, T^r and H^r make PTT decrease, while T^{-r} and H^{-r} make more than half number of countries’ PTT increase. T^r’s effect on PEM is positive, but on PEE is close to neutral. H^r has positive effects on PEM in most countries and negative effects on PEE in more than half number of countries. H^{-r}’s effects on PEE and PEM are positive and small in most of countries. T^{-r} makes PEE increase in more than half number of countries. With regard to final demand, d^r and q^r make PTT decrease, while d^{-r} and q^{-r} make PTT increase. Therefore, the effect of overall final demand on PTT is not as strong as the effect of production technology. Although the effect of d^{-r} is positive on both PEE and PEM in 3/4 countries, its effect on PTT is positive also in 3/4 countries. q^r and d^r have no effects on PEE, while d^r makes PEM increase in most countries and q^r’s effect on PEM is positive. q^{-r} makes PEE and PEM increase, but its effect on PEE is much larger.

4. Discussion and Conclusion

We find changes in final demand lead to all the countries’ imports and exports dirtier, but the increase (in percentage) of emission embodied in imports are larger than that of exports in many countries. The production technology makes all the countries’ imports and 26 countries’ exports dirtier; while it makes 14 countries’ exports cleaner. These 14 countries includes developed countries, such as United States, United Kingdom, Australia, Japan and Finland, and also includes some East European countries, such as Estonia, Romania, Slovak Republic, Hungary, Russia and Lithuania. It seems the technology spillover of Western European countries to Eastern European countries in the last decade leads to clear exports of Eastern European countries. The decrease of PEE are mainly brought by factors related to home countries (T^r and H^r) in the Eastern European countries (e.g. Estonia, Slovak Republic, Hungary, Lithuania and Czech Republic).

Final demand related to the domestic country (q^r and d^r) has almost no effect on PEE, which can be explained by the factor that exports are caused by foreign final demand and the second-order effects on PEE are very small. Foreign technology (H^{-r} and T^{-r}) has effects on PEE directly through the trade of intermediate products. We find that this effect is not smaller than the domestic technology effects. Final demand factors related to foreign countries (q^{-r} and d^{-r}) have positive effects on PEM. Even though the effects are much smaller than that of domestic final demand (q^r and d^r). Our decomposition analysis shows that foreign final demand could considerably affect the emission embodied in imports through the intermediate products, but domestic final demand’s effect on the emission embodied in exports is negligible. This is quite intuitive, because for changes in foreign final demand, imports of intermediate products in *all the countries* will affect the PEM, while for changes in domestic final demand, *only home country’s* exports of intermediate products account for the effects on PEE. In general, increases in consumption volume are the most important effect, weakly compensated by increases in efficiency (decrease of emission coefficients).

Improvement in efficiency makes both PEE and PEM decrease (except Indonesia). We find the emission coefficients effect on PEE and PEM are significantly negatively correlated, with the correlation coefficient -0.35 and p-value 0.025. Some countries changes more in the output emission than the others. In those countries, exports are cleaner in a larger extent than

the imports. Therefore, the PEE decreased more than the PEM. Countries with the largest improvement through emission intensities are Bulgaria, China, Romanian and Poland. Countries with the smallest improvement are Indonesia, Australia, Brazil and Estonia.

There are several countries, China, Indonesia, Romania and Japan, perform quite special in our analysis. China's PEE and PEM changes dramatically during 1995 to 2009. We find the large increase in PEE due to T^{-r} and d^{-r}, and the large increase in PEM due to q^r, d^{-r}, T^r and H^r, especially q^r. Therefore, changes in level of domestic final demand is the biggest reason that China's PEM increase. Besides, changes in the part of trade for foreign production in production technology and the part of trade for foreign consumption in final demand induce PEE increase in China. It indicates that the overall level of production technology and final demand in foreign countries are somehow unchanged, but the production and consumption are shifted to use Chinese products or intermediate products (or services). Indonesia is the only country that changes in emission intensity induce PEE increase. It's emission intensity in sector 4 (Textiles and Textile Products), 6 (Wood and Products of Wood and Cork), 7 (Pulp, Paper, Paper, Printing and Publishing), 13 (Machinery), 14 (Electrical and Optical Equipment), 15 (Transport Equipment), 16 (Manufacturing, Nec; Recycling), and 29 (Real Estate Activities) increased by more than 100% during 1995 to 2009. Romania has the lowest overall PTT ratio, because its PEE in 2009 reduced to half of that in 1995 (due to factors W, T^r and H^r), and its PEM in 2009 increased to more than double of that in 1995 (due to factor q^r). With cleaner production technology, better efficiency and higher domestic final demand, Romania's PTT decreased by 73%. Japan is the only country that changes in the domestic final demand level ($q^{r)}$ lead to decrease of PEM. The overall domestic final demand level is decreased during the past decade. For the other countries, although affected by the US housing crisis in 2008 and the global financial crisis afterwards, the overall domestic final demand level increased greatly between 1995 to 2009, leading to a large increase of emission embodied in imports in many countries.

Appendix

Table 1: Structural Decomposition Analysis Pollution Embodied in Exports (1995-2009)

	W	T^{r}	T^{-r}	H^{r}	H^{-r}	d^{r}	d^{-r}	q^{r}	q^{-r}	R_9509
Australia	0.98	0.94	0.90	0.99	1.09	1.00	0.97	1.00	1.54	1.33
Austria	0.61	0.98	1.26	1.08	1.02	1.00	1.25	1.00	1.35	1.41
Belgium	0.69	1.05	0.98	1.00	1.06	1.00	0.98	1.00	1.43	1.04
Bulgaria	0.39	0.82	0.84	1.42	1.17	1.00	1.17	1.00	1.50	0.78
Brazil	0.98	1.00	1.14	1.15	1.00	1.00	1.16	1.00	1.42	2.11
Canada	0.70	1.02	1.06	0.96	0.96	1.00	1.04	1.00	1.34	0.98
China	0.40	0.92	2.59	1.11	1.02	1.00	2.24	1.01	1.44	3.52
Cyprus	0.63	0.94	1.15	1.20	1.13	1.00	1.09	1.00	1.52	1.54
Czech Republic	0.66	0.89	1.33	0.84	0.99	1.00	1.43	1.00	1.33	1.23
Germany	0.70	1.01	1.18	1.06	1.03	1.01	1.12	1.00	1.48	1.51
Denmark	0.87	0.96	1.07	1.01	1.16	1.00	1.02	1.00	1.67	1.80
Spain	0.73	0.99	1.07	1.15	1.06	1.00	1.10	1.00	1.42	1.48
Estonia	0.94	0.88	1.09	0.61	1.07	1.00	1.11	1.00	1.49	0.97
Finland	0.77	1.00	1.04	0.89	0.99	1.00	1.01	1.00	1.47	1.05
France	0.54	1.04	1.03	0.97	1.05	1.00	1.06	1.00	1.43	0.89
United Kingdom	0.80	1.02	0.86	0.92	1.06	1.00	0.89	1.00	1.56	0.97
Greece	0.70	0.97	1.68	0.99	1.15	1.00	1.45	1.00	1.71	3.23
Hungary	0.78	0.91	1.16	0.84	1.01	1.00	1.41	1.00	1.41	1.41
Indonesia	1.07	1.00	1.02	1.15	1.01	1.00	1.09	1.00	1.47	2.02
India	0.89	0.96	1.40	0.79	0.98	1.00	1.69	1.00	1.40	2.20
Ireland	0.62	0.99	1.39	1.03	0.97	1.00	1.32	1.00	1.52	1.73
Italy	0.82	1.00	0.86	1.11	1.03	1.00	0.85	1.00	1.42	0.97
Japan	0.93	1.03	0.79	1.02	1.14	1.00	0.87	1.00	1.76	1.36
Korea	0.70	1.03	1.30	0.93	1.10	1.00	1.32	1.00	1.68	2.13
Lithuania	0.73	0.92	1.06	0.92	1.03	1.00	1.21	1.00	1.51	1.26
Luxembourg	0.73	0.99	1.34	1.06	1.00	1.00	1.22	1.00	1.56	1.96
Latvia	0.55	0.91	1.18	1.02	1.01	1.00	1.14	1.00	1.50	1.05
Mexico	0.81	1.06	1.21	0.93	0.95	1.00	1.25	1.00	1.38	1.58
Malta	0.63	0.97	1.14	1.20	1.07	1.00	1.18	1.00	1.50	1.60
Netherlands	0.59	0.99	0.99	1.05	1.06	1.00	0.99	1.00	1.37	0.88
Poland	0.51	0.92	1.67	0.69	1.02	1.00	1.69	1.00	1.29	1.21
Portugal	0.81	0.98	1.09	1.10	1.02	1.00	0.96	1.00	1.39	1.28
Romania	0.46	0.83	0.98	0.87	1.05	1.00	1.19	1.00	1.44	0.59
Russia	0.84	0.98	0.87	0.97	1.10	1.00	0.96	1.00	1.49	1.10
Slovak Republic	0.64	0.88	1.20	0.72	1.02	1.00	1.55	1.00	1.32	1.04
Slovenia	0.82	0.97	1.19	0.92	1.06	1.00	1.27	1.00	1.35	1.57
Sweden	0.72	1.06	1.01	0.94	1.05	1.00	0.96	1.00	1.56	1.13
Turkey	0.57	0.97	2.33	0.92	1.00	1.00	1.96	1.00	1.37	3.18
Taiwan	0.65	1.11	1.34	0.94	1.12	1.00	1.07	1.00	1.77	1.94
United States	0.86	1.00	0.89	0.81	1.09	1.01	0.93	1.01	1.60	1.05
RoW	0.73	1.00	1.38	1.23	1.20	1.01	1.12	1.01	1.45	2.48

Table 2: Structural Decomposition Analysis Pollution Embodied in Imports (1995-2009)

	W	T^{r}	T^{-r}	H^{r}	H^{-r}	d^{r}	d^{-r}	q^{r}	q^{-r}	R_9509
Australia	0.67	1.38	1.04	1.00	1.07	1.32	0.99	1.74	1.01	2.38
Austria	0.69	1.06	1.02	1.13	1.04	1.14	1.05	1.16	1.04	1.28
Belgium	0.68	1.16	1.04	1.03	1.08	1.17	0.98	1.16	1.09	1.32
Bulgaria	0.76	0.59	1.01	1.79	1.10	0.99	1.12	1.54	1.06	1.62
Brazil	0.72	1.32	1.06	1.20	1.04	1.23	1.01	1.37	1.02	2.16
Canada	0.73	1.04	1.06	1.11	0.98	1.11	1.02	1.64	1.04	1.70
China	0.77	1.38	1.01	1.32	1.00	1.04	1.34	3.34	1.06	7.03
Cyprus	0.73	0.81	1.03	1.28	1.06	0.93	1.02	1.48	1.02	1.18
Czech Republic	0.69	1.09	1.01	1.14	1.00	1.12	1.20	1.43	1.06	1.77
Germany	0.66	1.19	1.03	1.03	1.01	1.26	1.02	1.01	1.06	1.15
Denmark	0.70	1.19	1.05	1.05	1.02	1.15	0.99	1.10	1.09	1.27
Spain	0.70	1.18	1.05	1.17	1.09	1.19	1.03	1.44	1.04	2.03
Estonia	0.74	0.93	1.02	1.19	0.98	1.05	1.07	1.64	1.07	1.60
Finland	0.74	1.08	1.03	1.10	0.97	1.04	1.02	1.32	1.07	1.30
France	0.70	0.99	1.05	1.05	1.06	1.08	1.04	1.50	1.04	1.44
United Kingdom	0.69	1.28	1.05	0.95	1.03	1.31	0.98	1.22	1.04	1.47
Greece	0.68	1.17	1.03	1.09	1.10	1.22	1.03	1.70	1.03	2.15
Hungary	0.70	1.07	1.02	1.19	1.01	1.13	1.19	1.22	1.07	1.62
Indonesia	0.70	1.18	1.04	1.21	1.09	1.22	1.03	1.41	1.03	2.05
India	0.73	1.39	1.05	1.04	1.11	1.12	1.12	2.62	1.01	4.12
Ireland	0.70	1.15	1.08	1.18	0.97	1.10	1.08	1.62	1.14	2.21
Italy	0.68	1.11	1.04	1.38	1.07	1.12	0.96	1.10	1.04	1.42
Japan	0.67	1.29	1.02	1.13	1.11	1.20	0.98	0.87	1.03	1.16
Korea	0.69	1.14	1.03	1.18	1.10	1.06	1.12	1.31	1.08	1.75
Lithuania	0.79	0.99	1.02	1.22	0.98	0.95	1.07	1.77	1.07	1.84
Luxembourg	0.69	1.07	1.08	1.11	1.06	0.96	1.07	1.41	1.14	1.54
Latvia	0.74	0.88	1.00	1.42	0.94	0.95	1.03	1.78	1.03	1.57
Mexico	0.71	1.36	1.06	1.08	0.92	1.30	1.10	1.60	1.06	2.50
Malta	0.72	1.06	1.06	1.17	1.09	1.09	0.96	1.11	1.08	1.30
Netherlands	0.69	1.17	1.04	1.07	1.08	1.13	1.00	1.17	1.07	1.38
Poland	0.72	1.19	1.02	1.08	1.03	1.18	1.21	1.98	1.02	2.77
Portugal	0.71	1.03	1.06	1.35	1.11	1.03	0.98	1.28	1.03	1.55
Romania	0.71	1.13	1.02	1.05	1.04	1.14	1.07	2.00	1.02	2.21
Russia	0.63	1.12	1.04	1.06	1.07	1.28	0.99	1.95	1.01	2.06
Slovak Republic	0.70	1.06	1.01	1.09	0.98	1.07	1.33	1.70	1.05	2.03
Slovenia	0.69	1.11	1.03	1.05	1.13	1.13	1.10	1.32	1.05	1.61
Sweden	0.71	1.20	1.04	1.00	1.02	1.15	1.01	1.18	1.09	1.35
Turkey	0.70	1.08	1.02	1.28	1.08	1.15	1.14	1.65	1.03	2.35
Taiwan	0.71	1.02	1.04	0.91	1.06	1.05	0.98	1.21	1.15	1.04
United States	0.65	1.42	1.05	0.96	1.06	1.35	1.00	1.30	1.02	1.75
RoW	0.71	1.26	1.00	1.08	1.00	1.16	1.03	1.76	1.04	2.11

Table 3: Structural Decomposition Analysis Pollution Terms of Trade (1995-2009)

	W	T^{r}	T^{-r}	H^{r}	H^{-r}	d^{r}	d^{-r}	q^{r}	q^{-r}	R_9509
Australia	1.46	0.68	0.86	0.99	1.02	0.76	0.98	0.58	1.52	0.56
Austria	0.89	0.93	1.23	0.95	0.98	0.88	1.18	0.86	1.30	1.10
Belgium	1.01	0.90	0.94	0.97	0.98	0.85	1.00	0.86	1.32	0.79
Bulgaria	0.51	1.37	0.83	0.79	1.07	1.01	1.05	0.65	1.41	0.48
Brazil	1.37	0.76	1.08	0.96	0.96	0.81	1.15	0.73	1.39	0.97
Canada	0.95	0.98	1.00	0.87	0.98	0.90	1.03	0.61	1.29	0.57
China	0.52	0.66	2.55	0.84	1.02	0.96	1.67	0.30	1.36	0.50
Cyprus	0.87	1.16	1.11	0.94	1.06	1.08	1.08	0.67	1.49	1.31
Czech Republic	0.95	0.82	1.31	0.73	0.99	0.89	1.19	0.70	1.25	0.69
Germany	1.06	0.85	1.15	1.03	1.02	0.80	1.10	0.99	1.41	1.32
Denmark	1.25	0.81	1.02	0.96	1.14	0.87	1.03	0.91	1.52	1.41
Spain	1.05	0.83	1.02	0.99	0.97	0.84	1.07	0.69	1.36	0.73
Estonia	1.27	0.95	1.07	0.51	1.09	0.95	1.04	0.61	1.40	0.61
Finland	1.05	0.93	1.01	0.81	1.02	0.96	1.00	0.76	1.38	0.81
France	0.77	1.04	0.98	0.92	0.99	0.93	1.02	0.67	1.37	0.62
United Kingdom	1.17	0.80	0.82	0.97	1.03	0.77	0.92	0.82	1.50	0.66
Greece	1.03	0.83	1.64	0.92	1.05	0.82	1.40	0.59	1.67	1.50
Hungary	1.12	0.85	1.13	0.71	1.01	0.89	1.18	0.82	1.32	0.87
Indonesia	1.53	0.85	0.97	0.95	0.93	0.82	1.06	0.71	1.43	0.99
India	1.22	0.69	1.33	0.76	0.89	0.90	1.51	0.38	1.38	0.53
Ireland	0.89	0.86	1.29	0.87	1.01	0.91	1.22	0.62	1.33	0.78
Italy	1.19	0.90	0.84	0.80	0.97	0.89	0.88	0.91	1.36	0.68
Japan	1.39	0.80	0.77	0.91	1.03	0.84	0.90	1.15	1.70	1.18
Korea	1.01	0.91	1.27	0.79	1.00	0.95	1.18	0.77	1.55	1.22
Lithuania	0.92	0.93	1.05	0.76	1.06	1.05	1.13	0.56	1.42	0.68
Luxembourg	1.06	0.93	1.24	0.96	0.94	1.04	1.14	0.71	1.36	1.27
Latvia	0.74	1.03	1.18	0.72	1.08	1.05	1.10	0.56	1.45	0.67
Mexico	1.13	0.78	1.14	0.86	1.03	0.77	1.14	0.63	1.30	0.63
Malta	0.88	0.91	1.08	1.03	0.98	0.92	1.23	0.90	1.39	1.23
Netherlands	0.85	0.85	0.95	0.98	0.99	0.88	0.99	0.85	1.28	0.64
Poland	0.71	0.78	1.63	0.64	0.99	0.85	1.40	0.51	1.26	0.44
Portugal	1.14	0.95	1.04	0.81	0.92	0.97	0.97	0.78	1.34	0.83
Romania	0.65	0.74	0.96	0.83	1.01	0.88	1.11	0.50	1.41	0.27
Russia	1.34	0.88	0.84	0.91	1.03	0.78	0.97	0.51	1.47	0.53
Slovak Republic	0.92	0.83	1.19	0.67	1.04	0.94	1.16	0.59	1.26	0.51
Slovenia	1.19	0.87	1.16	0.88	0.93	0.89	1.15	0.76	1.28	0.97
Sweden	1.02	0.88	0.97	0.94	1.03	0.87	0.95	0.84	1.43	0.84
Turkey	0.82	0.90	2.29	0.71	0.93	0.87	1.72	0.61	1.34	1.35
Taiwan	0.92	1.09	1.29	1.04	1.06	0.95	1.09	0.83	1.54	1.87
United States	1.32	0.71	0.85	0.85	1.03	0.75	0.94	0.78	1.57	0.60
RoW	1.03	0.80	1.38	1.14	1.20	0.87	1.09	0.58	1.40	1.17

Table 4: Structural Decomposition Analysis Pollution Terms of Trade in order (1995-2009)

	W	T	H	A	d	q	F	R_9509
Romania	0.65	0.71	0.84	0.59	0.98	0.70	0.69	0.27
Poland	0.71	1.27	0.64	0.81	1.19	0.64	0.76	0.44
Bulgaria	0.51	1.14	0.84	0.96	1.06	0.92	0.98	0.48
China	0.52	1.70	0.85	1.45	1.61	0.41	0.66	0.50
Slovak Republic	0.92	0.99	0.70	0.69	1.09	0.74	0.81	0.51
Russia	1.34	0.74	0.94	0.69	0.76	0.76	0.57	0.53
India	1.22	0.91	0.67	0.61	1.35	0.53	0.71	0.53
Australia	1.46	0.59	1.00	0.59	0.74	0.88	0.65	0.56
Canada	0.95	0.97	0.85	0.83	0.92	0.79	0.73	0.57
United States	1.32	0.60	0.87	0.53	0.71	1.22	0.86	0.60
Estonia	1.27	1.02	0.56	0.57	0.99	0.86	0.84	0.61
France	0.77	1.02	0.91	0.93	0.94	0.91	0.86	0.62
Mexico	1.13	0.89	0.89	0.78	0.88	0.81	0.71	0.63
Netherlands	0.85	0.81	0.97	0.78	0.87	1.09	0.95	0.64
United Kingdom	1.17	0.65	1.00	0.65	0.70	1.23	0.86	0.66
Latvia	0.74	1.22	0.78	0.95	1.16	0.81	0.94	0.67
Lithuania	0.92	0.97	0.80	0.78	1.19	0.80	0.95	0.68
Italy	1.19	0.75	0.78	0.59	0.79	1.24	0.98	0.68
Czech Republic	0.95	1.07	0.72	0.78	1.06	0.88	0.93	0.69
Spain	1.05	0.85	0.96	0.81	0.90	0.95	0.85	0.73
Ireland	0.89	1.10	0.88	0.97	1.11	0.82	0.91	0.78
Belgium	1.01	0.85	0.95	0.80	0.85	1.14	0.97	0.79
Finland	1.05	0.94	0.83	0.77	0.96	1.05	1.00	0.81
Portugal	1.14	0.98	0.75	0.73	0.95	1.05	1.00	0.83
Sweden	1.02	0.85	0.97	0.83	0.83	1.21	1.00	0.84
Hungary	1.12	0.96	0.71	0.69	1.05	1.08	1.13	0.87
Slovenia	1.19	1.01	0.82	0.83	1.02	0.97	0.99	0.97
Brazil	1.37	0.82	0.92	0.75	0.93	1.02	0.95	0.97
Indonesia	1.53	0.83	0.88	0.73	0.87	1.01	0.88	0.99
Austria	0.89	1.14	0.93	1.06	1.04	1.12	1.17	1.10
RoW	1.03	1.10	1.36	1.49	0.95	0.80	0.76	1.17
Japan	1.39	0.62	0.93	0.58	0.75	1.95	1.47	1.18
Korea	1.01	1.15	0.79	0.91	1.12	1.19	1.33	1.22
Malta	0.88	0.98	1.01	0.99	1.13	1.25	1.41	1.23
Luxembourg	1.06	1.15	0.90	1.04	1.19	0.96	1.15	1.27
Cyprus	0.87	1.29	1.00	1.29	1.16	1.00	1.17	1.31
Germany	1.06	0.97	1.05	1.01	0.88	1.40	1.23	1.32
Turkey	0.82	2.06	0.66	1.36	1.49	0.81	1.22	1.35
Denmark	1.25	0.83	1.09	0.91	0.90	1.38	1.24	1.41
Greece	1.03	1.35	0.96	1.30	1.14	0.98	1.12	1.50
Taiwan	0.92	1.40	1.10	1.54	1.04	1.27	1.32	1.87

Figure 1: Ratios of PEE (PEM) in 2009 to PEE (PEM) in 1995

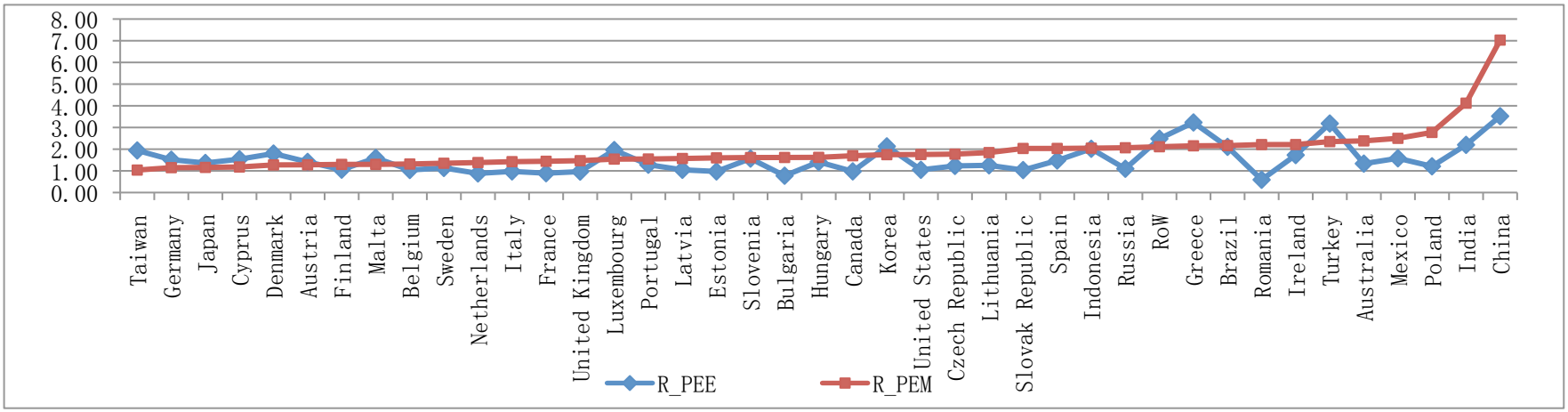

Figure 2: SDA of PEE (Emission Intensity, Production Technology and Final Demand)

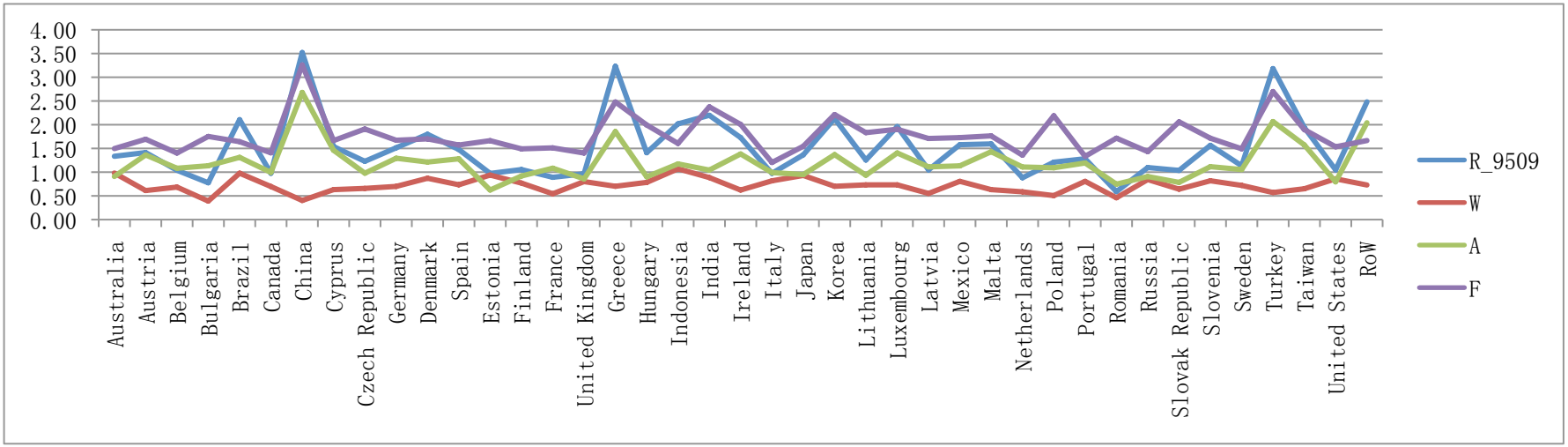

Figure 3: SDA of PEM (Emission Intensity, Production Technology and Final Demand)

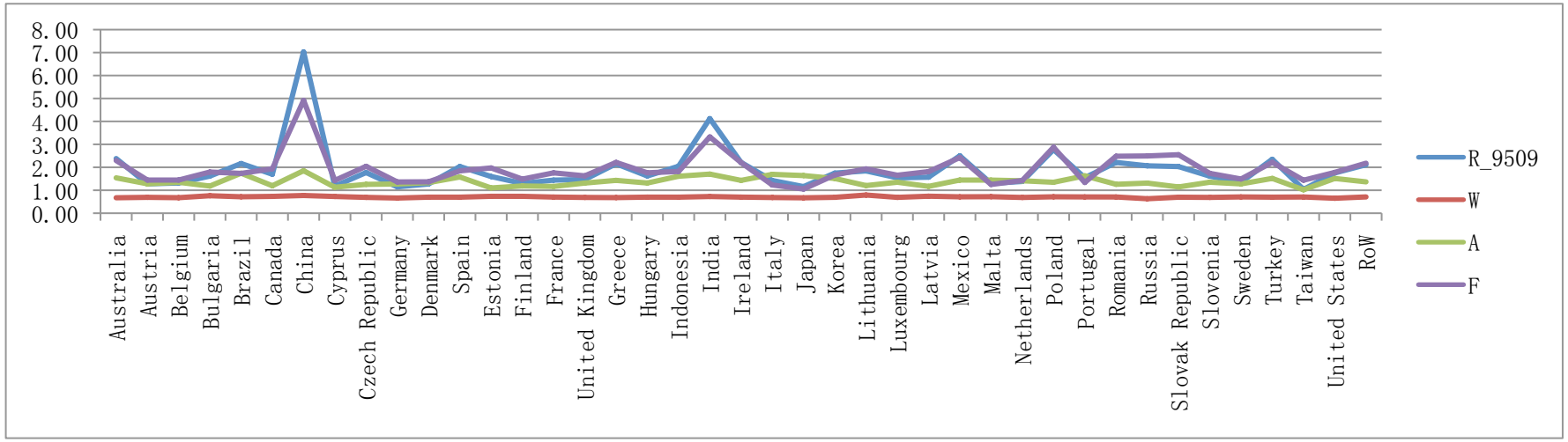

Figure 4: Emission Intensity Effects on PEE and PEM

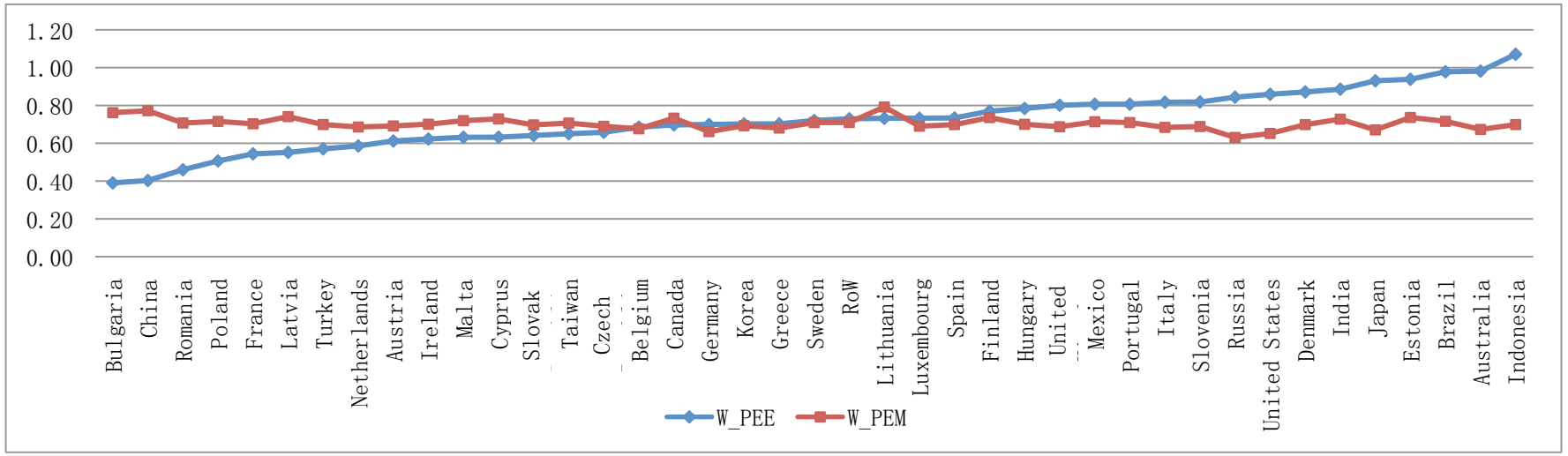

Figure 5: Production Technology Effects on PEE and PEM

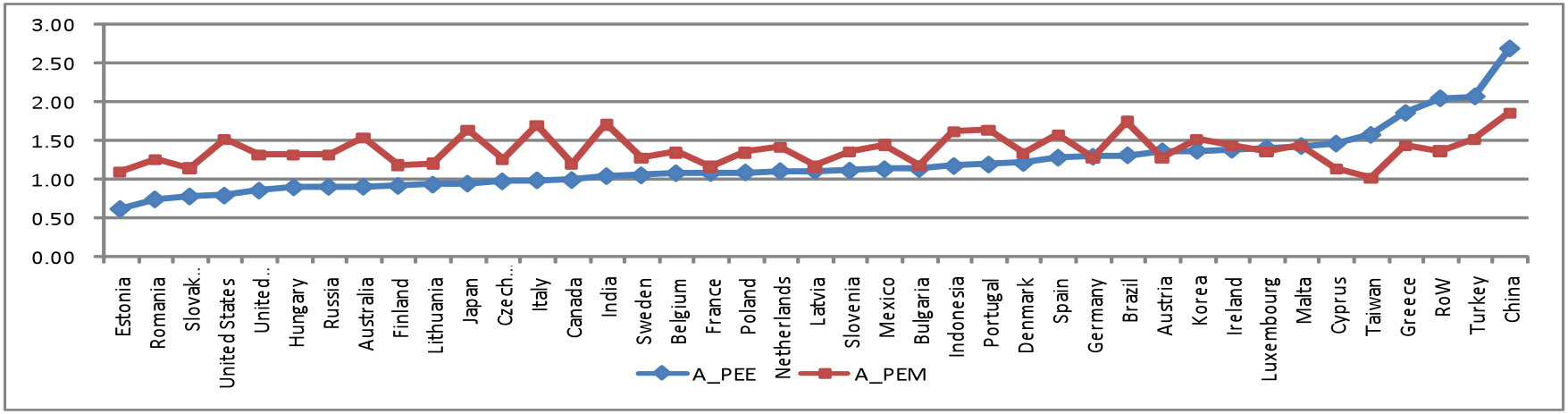

Figure6: Decomposition part associated with technology

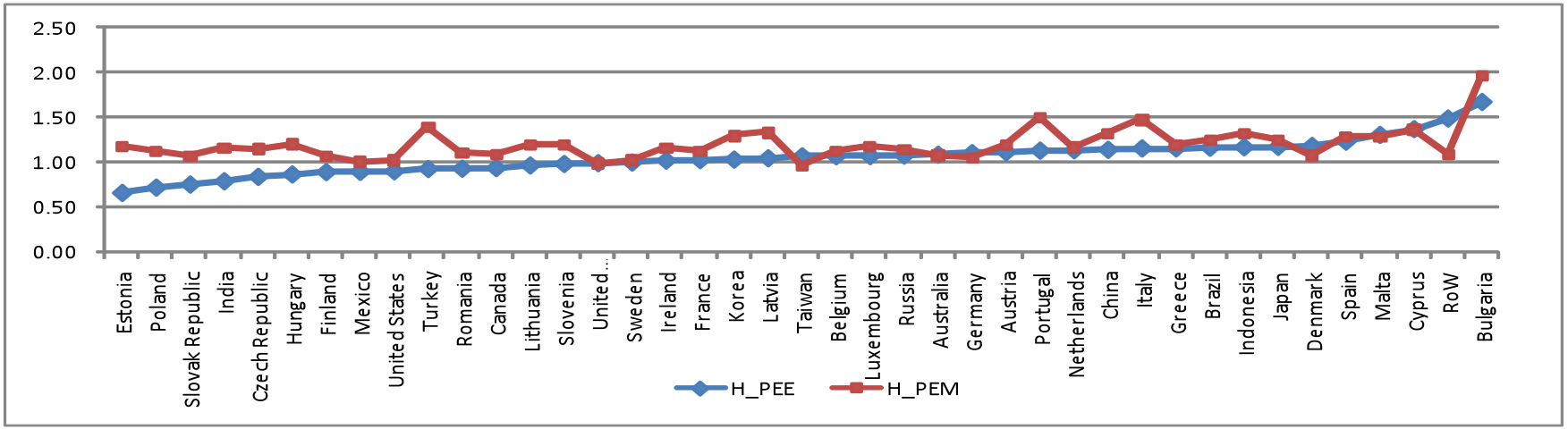

Figure 7: Decomposition part associated with trade

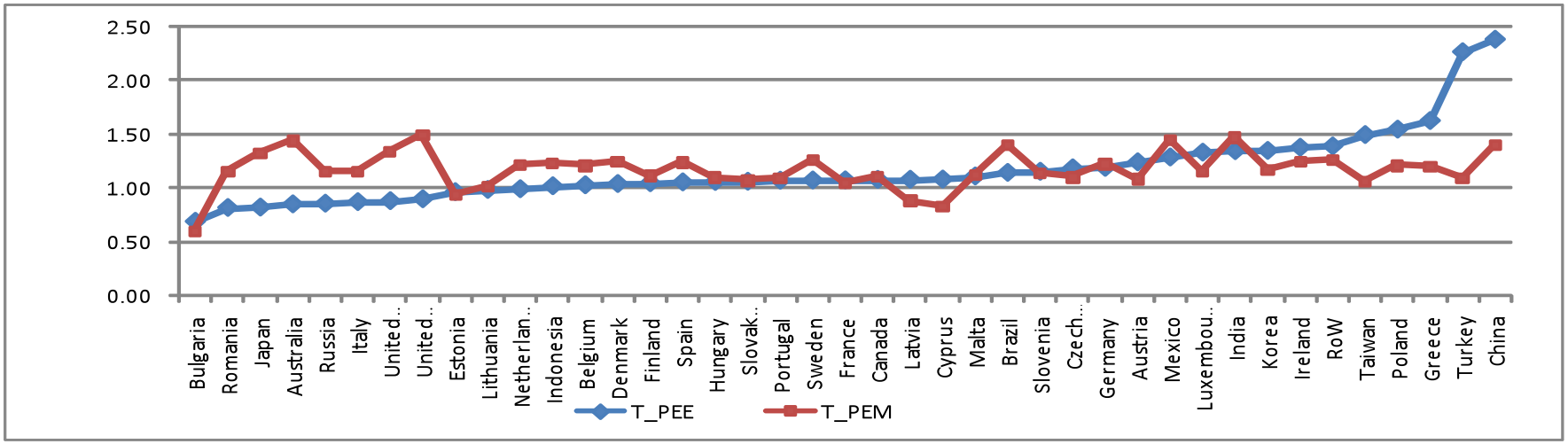

Figure 8: Final Demand Effect on PEE and PEM

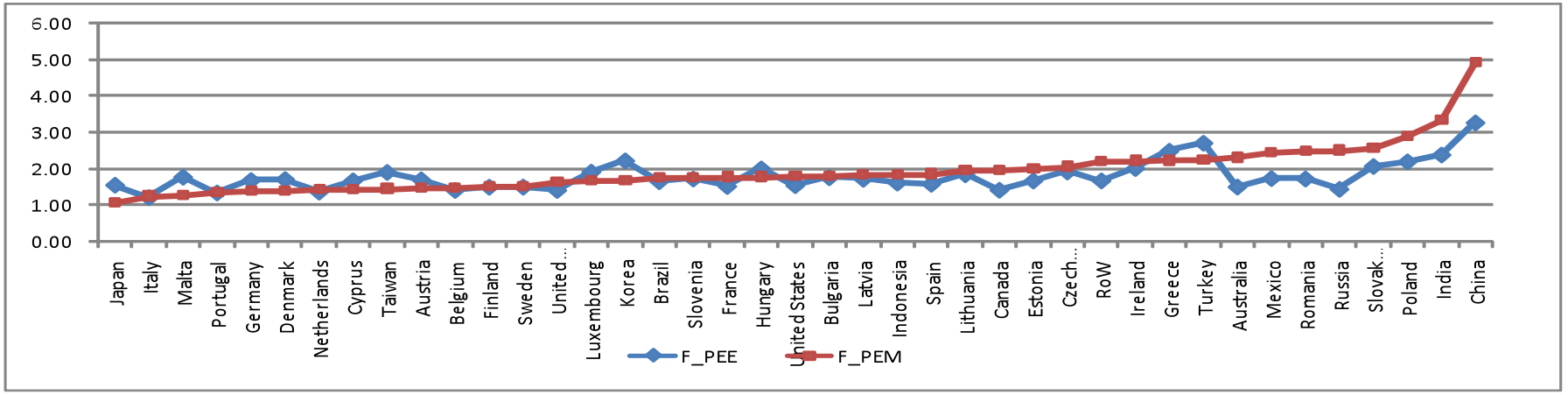

Figure 9: Decomposition part reflects overall final demand

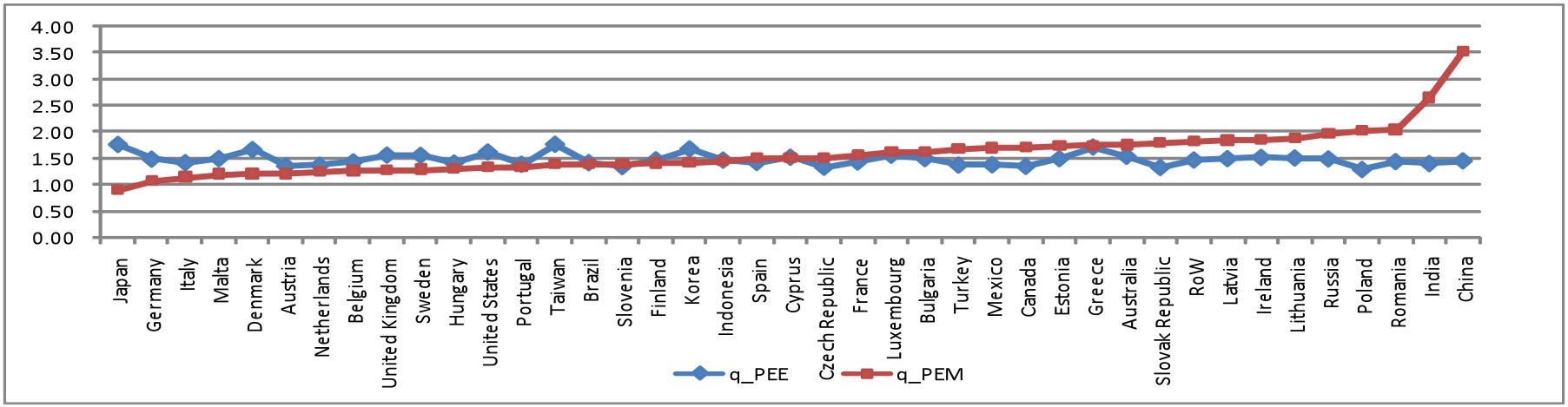

Figure 10: Decomposition part reflects trade of final demand

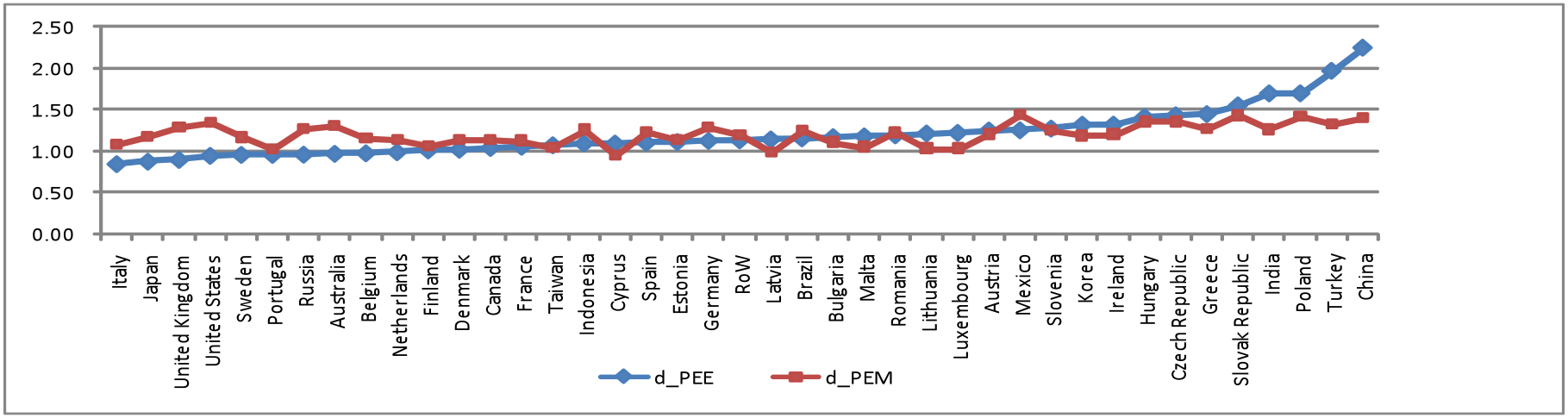

Figure 11: Pollution Terms of Trade Ratios

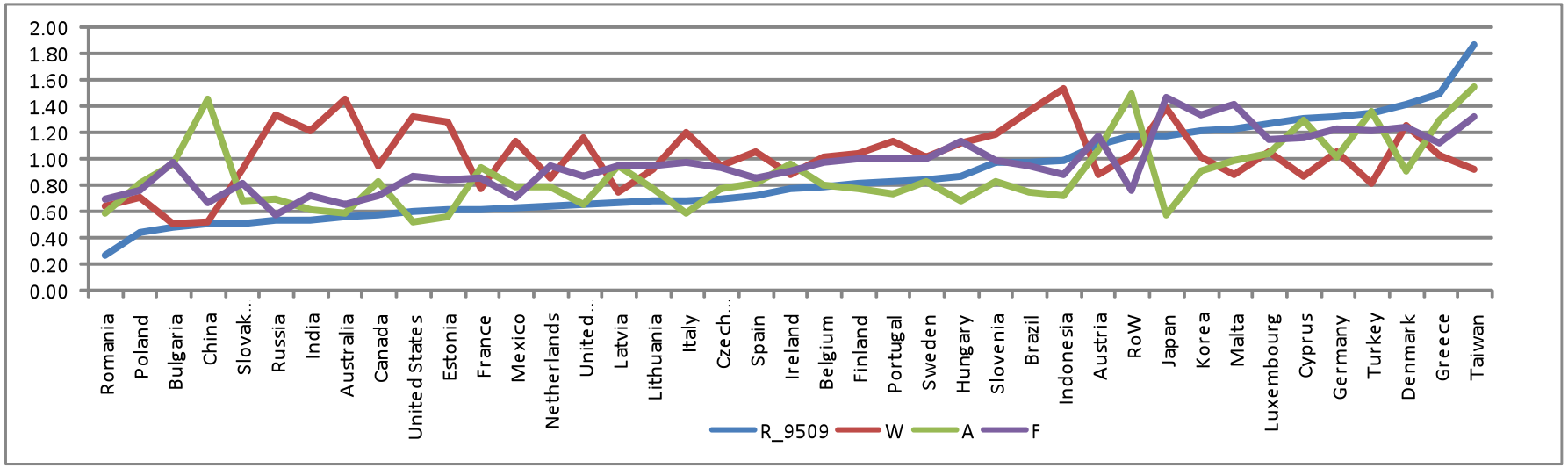

Table 5: Effects of Factors

	W	T^{r}	T^{-r}	H^{r}	H^{-r}	d^{r}	d^{-r}	q^{r}	q^{-r}	R_9509
PEE	1+ 39−	15+ 25−	30+ 10−	18+ 22−	34+ 6−	no eff	30+ 10−	no eff	+	32+ 8−
PEM	−	34+ 6−	+	37+ 3−	32+ 8−	35+ 5−	30+ 10−	39+ 1−	+	+
PTT	23+ 17−	5+ 35−	27+ 13−	3+ 37−	23+ 17−	5+ 35−	31+ 9−	1+ 39−	+	11+ 29−
	W	T	H		A	d	q		F	R_9509
PEE	1+ 39−	29+ 11−	24+ 16−		26+ 14−	30+ 10−	+		+	32+ 8−
PEM	−	36+ 4−	38+ 2−		+	38+ 2−	+		+	+
PTT	23+ 17−	16+ 24−	7+ 33−		8+ 32−	19+ 21−	19+ 21−		15+ 25−	11+ 29−

Note: “+” and “-” indicate “increase” and “decrease”, and number of countries are written before signs. “no eff” means no effect.

Table 6: List of Sectors

1	Agriculture, Hunting, Forestry and Fishing
2	Mining and Quarrying
3	Food, Beverages and Tobacco
4	Textiles and Textile Products
5	Leather, Leather and Footwear
6	Wood and Products of Wood and Cork
7	Pulp, Paper, Paper , Printing and Publishing
8	Coke, Refined Petroleum and Nuclear Fuel
9	Chemicals and Chemical Products
10	Rubber and Plastics
11	Other Non-Metallic Mineral
12	Basic Metals and Fabricated Metal
13	Machinery, Nec
14	Electrical and Optical Equipment
15	Transport Equipment
16	Manufacturing, Nec; Recycling
17	Electricity, Gas and Water Supply
18	Construction
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods
22	Hotels and Restaurants
23	Inland Transport
24	Water Transport
25	Air Transport
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	Post and Telecommunications
28	Financial Intermediation
29	Real Estate Activities
30	Renting of M&Eq and Other Business Activities
31	Public Admin and Defence; Compulsory Social Security
32	Education
33	Health and Social Work
34	Other Community, Social and Personal Services
35	Private Households with Employed Persons