자원 · 환경경제연구 제 16권 제 3호
Environmental and Resource Economics Review
Volume 16, Number 3, Septmber 2007 : pp. 723~738

Decomposition of CO_2 Emissions in the Manufacturing Sector :

An International Comparative Study for Korea, UK, and USA*

Taek Whan Han** and Wonzoe Shin***

〈Contents〉

* This paper is a revised version of the paper of the same title presented at the international seminar "Rethinking Sustainable Development in East Asia, Korea Environmental Economics Association, November 2006, Seoul, Korea. The authors thank an anonymous referee for his/her valuable comments."
** Professor of Economics, Seo-Kyeong University.
*** Research Fellow, Korea Institute for Environment and Security.

Ⅰ. Introduction

This paper draws some policy implications from the Divisia decomposition analysis on the sources of CO_2 emission changes in the manufacturing sectors of Korea, UK, and USA. Decomposition analysis has been widely applied to researches on the energy use and/or greenhouse gas emission analysis. The sources of change in CO_2 emission of the manufacturing sector are decomposed into three factors: production scale factor, structural factor, and technical factor.

Korea, USA, and UK are chosen for this analysis on the implication of CO_2 emission changes in each country's manufacturing sector.[1] There

1) The countries are selected by the following reasons. Initially, five countries including Korea, Japan, China, UK, Australia and USA were considered. The rationale for the selection of these countries are as follows. China is the representative developing country and has very important implications to the future of Kyoto system itself. "Meaningful participation" of China, if realized, would have profound impact on the world economy. Finding the source of CO_2 emission changes is very important However, the data for China is almost blank in the OECD Energy Balance Data database. Japan is also important in the it is a unique in overcoming energy crisis in the 70's and has been successful in converting the economy into environmentally sound one. However, Japan was deleted from the country list because of inconsistencies found in the OECD industrial data set. Australia is an important country because it is a non member to the Kyoto Protocol along with the USA, and also because it is a highly fossil fuel dependent economy. Australia has worked closely with Korea in the negotiation process with Korea since two countries share commonality as high dependency on fossil fuels. USA is selected both because of its predominance in the world economy and non-membership to the Kyoto Protocol. United Kingdom is selected because its leadership in combating climate change and excellent performance in reducing greenhouse gas emissions. Among the industrialized countries, UK is unique country that has shown trend decreasing in actual energy

has been several international comparative studies using decomposition technique.[2] The differences among three countries in the decomposition result represents variations in their endowments and policy environments. It also gives some implications on the future policy formulations for the countries in question, particularly for Korea.

Ⅱ. Methodology and Data

An overview of index decomposition method has been reported by Ang and Zhang (2000). The method of index decomposition analysis uses aggregate date at sectoral level to compute the factors that attribute the total changes. Another competing method is the structural decomposition method which uses input-output table to quantify the sources of change. Rose and Casler (1996) reviewed on the input-output decomposition analysis method. The Divisia decomposition method is a common approach that is adopted by many researchers in the recent studies. Oh (2003) and Chung and Lee (2001) applied this line of research method for their studies of the changes in energy use and CO_2 emission in Korean industrial sectors.

---

use (Unander, 2007). Out of these five countries of initial consideration, UK, USA, and Korea was selected because of reliable data availability.

2) Lee and Oh (2006) used a decomposition technique for the international comparison among APEC member countries, without considering industrial structure, for the years of 1980 and 1998. Unander (2007) performed a decomposition analysis regarding energy use (not CO_2 emission), in the manufacturing sector for the comparison among IEA countries, which did not include Korea.

There are several versions of Divisia decomposition techniques. We used both Simple Mean Parametric Divisia Method (SMPDM)[3] and Logarithmic Mean Weight Divisia Method (LMWDM)[4] to compute components of production, structural and technical changes from the CO_2 emission data on manufacturing sectors of the selected countries. Simple Mean Parametric Divisia Method (SMPDM) applies same weight to the values of base year and the year compared, then it uses log values of ratios instead of differences between the comparing years. The SMPDM is useful for identifying the sources of changes with the data obtained from decomposing the factors of CO_2 emission change. However, this method has a flaw that it sometimes results in a large unacceptable size of residuals. To handle this problem, LMWDM in which residual is eliminated has been adopted.[5] In this paper, only the result from the

---

3) Simple Mean PDM index is obtained from the following equations by setting $\alpha=\beta=\gamma=0.5$

$$(\varDelta E_P)_{0,t}=[E_0+\alpha(E_t-E_0)]\ln(Y_t/Y_0)$$

$$(\varDelta E_S)_{0,t}=\Sigma_i[E_{i,0}+\beta_i(E_{i,t}-E_{i,0})]\ln(S_{i,t}/S_{i,0})$$

$$(\varDelta E_T)_{0,t}=\Sigma_i[E_{i,0}+\gamma_i(E_{i,t}-E_{i,0})]\ln(T_{i,t}/T_{i,0})$$

where $(\varDelta E)_{0,t}=(\varDelta E_P)_{0,t}+(\varDelta E_S)_{0,t}+(\varDelta E_{Tt})_{0,t}+(\varDelta E_R)_{0,t}$

where $(\varDelta E)_{0,t}$ implies total CO_2 emission change from 0 to t, $(\varDelta E_P)_{0,t}$ implies CO_2 emission change from 0 to t induced by change in production scale, $(\varDelta E_S)_{0,t}$ implies CO_2 emission change from 0 to t induced by change in structural change, $(\varDelta E_T)_{0,t}$ implies CO_2 emission change from 0 to t induced by change in technical change, and $(\varDelta E_R)_{0,t}$ is the residual term. S_i indicates share of sector i in the whole manufacturing sector, T_i implies the CO_2 emission intensity of the sector i. Subscript t and 0 means period t and period 0 respectively.

4) Logarithmic Mean Weight Divisia Method uses the Log Divisia weight, $L(E_{i,t},E_{i,0})=\dfrac{(E_{i,t}-E_{i,0})}{\ln(E_{i,t}/E_{i,0})}$, instead of the arithmetic average weight shown in footnote 2.

computation using LMWDM is reported. Data is obtained from the OECD/IEA Energy Balance Data set. For data consistency, mostly the IEA data set is used, and some recent data are supplemented from each country.

The data are obtained from the IEA Energy Balance Data set. For data consistency, mostly the IEA data set is used, and some recent data are supplemented from each country.

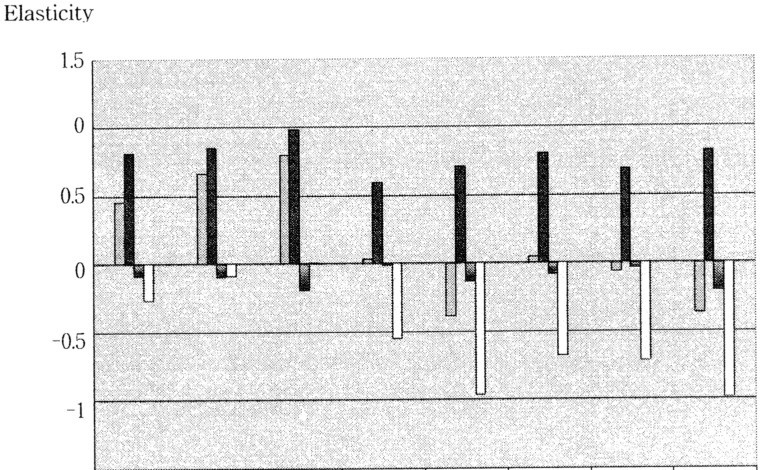
Using the IEA energy balance data, the emission quantities for each subsector for each country in each year was computed by energy input multiplied by the each emission coefficient for each primary energy source. For the electricity, emission coefficient was computed for each country in each year, by using the composition of primary energy sources used for the electricity generation.

Ⅲ. The Result

The decomposition result is shown in <Table 1> and <Figure 1>. It is reported for the periods of 1970 (or 1971) to 1980 (or 1979), 1980(or 1985)

5) Thus, a conspicuous difference between SMPDM and LMWDM is that SMPDM has non-zero residual value in the decomposition result while decomposition result using LMWDM gives zero residual value. Generally, a methodology with zero residual value has been regarded to be better one than a method providing non-zero residual value. Lenzen (2006) and Han and Shin (2005) tried to interpret the implication of residuals in those decompositions, and suggested that a zero residual value does not necessarily guarantee best interpretation for the decomposition results.

〈Figure 1〉 Decomposition of CO_2 Emissions in Three Countries in Elasticity Terms



	KOR8590	KOR9000	KOR0003	USA7180	USA8090	USA9099	UK8090	UK9000
Total Emission Change	0.45466449	0.66504	0.7938414	0.03328	-0.38298	0.04606	-0.06238	-0.36523
Due to Production	0.80790583	0.84545	0.97773268	0.59086	0.70839	0.7994	0.68596	0.82425
Due to Structure	-0.0865862	-0.0916	-0.1914383	-0.00765	-0.1314	-0.07894	-0.03557	-0.20276
Due to Technique	-0.2666551	-0.08882	0.00754701	-0.54994	-0.95998	-0.67441	-0.71276	-0.9867

Country/Period

Total Emission Change　Due to Production
Due to Structure　Due to Technique

to 1990, 1990 to 2000(or 1999), and 2000 to 2003. <Figure 1> illustrates the relative size of each element in elasticity terms for each country during each period.

In <Table 1>, 'due to production' means the CO_2 emission change induced by the production level change. 'Due to structure' means the CO_2 emission change caused by the change in the composition of subsectors in the manufacturing sector. 'Due to technique' means the CO_2 emission change brought by the technical change in each subsector. The 'technique'

〈Table 1〉 Decomposition of CO_2 Emission Changes in Korea, USA, Japan, UK(Logarithmic Mean Weight Divisia Method)

(Unit : thousand ton)

Korea (Republic of)	Year 1985 → 1990					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		7,255.52	12,847.58	-1,379.93	-4,212.13	0.00
		100.00%	177.07%	-19.02%	-58.05%	0.00%
	Elasticities	Total Change (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		0.45667	0.80865	-0.08685	-0.26512	n.a.
	Year 1990 → 2000					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		27,956.31	35,540.41	-3,850.52	-3,733.58	0.00
		100.00%	127.13%	-13.77%	-13.36%	0.00%
	Elasticities	Total Change (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		0.66504	0.84545	-0.09160	-0.08882	n.a.
	Year 2000 → 2003*					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		5,804.408	7,123.137	-1,573.680	254.951	0.00
		100.00%	123.17%	-24.12%	0.95%	0.00
	Elasticities	Total Change (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		0.796934	0.977993	-0.21606	0.03500	n.a.

U. S. A.	Year 1971 → 1980					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		21046.58	373689.84	-4836.26	-347807.00	0.00
		100.00%	1775.54%	-22.98%	-1652.56%	0.00%
	Elasticities	Total (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		0.03328	0.59086	-0.00765	-0.54994	n.a.
	Year 1980 → 1990					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		-78185.66	144618.58	-26824.83	-195979.42	0.00
		100.00%	-184.97%	34.31%	250.66%	0.00%
	Elasticities	Total (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		-0.38298	0.70839	-0.13140	-0.95998	n.a.
	Year 1990 → 1999					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		5668.89	98396.61	-9716.18	-83011.54	0.00
		100.00%	1735.73%	-171.39%	-1464.34%	0.00%
	Elasticities	Total (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		0.04606	0.79940	-0.07894	-0.67441	n.a.

United Kingdom	Year 1980→1990					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		-2126.35	23382.42	-1212.64	-24296.16	0.00
		100.00%	-1099.65%	57.03%	1142.63%	0.00%
	Elasticities	Total (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		-0.06238	0.68596	-0.03557	-0.71276	n.a.
	Year 1990→2000					
	CO_2 Emissions	Total Change (ΔE)	Due to Production (ΔE_P)	Due to Structure (ΔE_S)	Due to Technique (ΔE_T)	Residual (ΔE_R)
		-3748.48	8459.59	-2081.20	-10126.87	0.00
		100.00%	-225.68%	55.52%	270.16%	0.00%
	Elasticities	Total (ε)	Due to Production (ε_P)	Due to Structure (ε_S)	Due to Technique (ε_T)	Residual
		-0.36523	0.82425	-0.20278	-0.98670	n.a.

Source : Computed using OECD Energy Balance Data and OECD Industry Data (from CD and website). Data for Korea in 2003 were obtained form KOSIS database of National Statistical Office (Korea).

Note : * The figures for the 2000~2003 interval for Korea is tentative, since Korean NSO data, instead of IEA data, areused for the year 2003.

here implies the emission coefficient for each subsector. To make international and inter-period comparison more convenient, the elasticity[6)] of each emission change is computed and reported in <Table 1>.

1. 1980~1990 Period

The total elasticity of CO_2 emission in the manufacturing sector during 1980~1990 period (1985~1990 for Korea) was 0.45667 for Korea, -0.383 for USA, -0.062 for UK respectively. Among the three countries for comparison, Korea is the only country with positive figure.

Korea's total elasticity of 0.45667 is decomposed into production scale factor of 0.80865, structural factor of -0.08685, and technical change factor of -0.265. Korea has experienced a rise in CO_2 intensity both for the whole economy and for the manufacturing sector during the 80's.

Moreover, its relative contribution of technical change to the CO_2 emission reduction was the smallest in Korea amongst the countries. The relative contribution of industrial structural change to the emission reduction in Korea was the second to the smallest among the countries in comparison.

In general, Korea's CO_2 emission increase was mainly generated by scale factor and partially mitigated by technical factor in the 80's.

---

6) Total elasticity of CO_2 emission is decomposed as $\varepsilon = \varepsilon_P + \varepsilon_S + \varepsilon_T + \varepsilon_R$. Each element of this equation is defined as $\varepsilon = \frac{(\Delta E)/E_0}{\Delta Y/Y_0}$, $(\varepsilon_P) = \frac{(\Delta E_P)/E_0}{\Delta Y/Y_0}$ $(\varepsilon_S) = \frac{(\Delta E_S)/E_0}{\Delta Y/Y_0}$, and $(\varepsilon_T) = \frac{(\Delta E_T)/E_0}{\Delta Y/Y_0}$, where p implies production, s implies structure, T implies technique, and R implies residual. We use elasticity rather than the emission change quantity itself for the easiness of intercountry comparison.

2. 1990~2000 Period

The emission change patterns in the manufacturing sector from 1990 to 2000 for the countries in comparison experienced meaningful change compared to the previous period of 80's.

USA and Korea's production elasticity are increased for the previous period of 80's, while those of UK decreased from the previous ones. The total elasticity of CO_2 emission from 1990 to 2000 was 0.66504 for Korea, 0.04606 for USA, and -0.36523 for UK. We can infer that the policies and stances of Korea and USA regarding the UNFCCC and Kyoto Protocol might be related with these changes in the 90's.

In the period from 1990 to 2000 (1990 to 1999 for USA), major force lowering the CO_2 emission was the technical factor. However, the degree of contribution of technical factor to the reduction of CO_2 emission varies among the countries. It was -13.36% for Korea, -1464.34% for USA, and -270.6% for UK.

3. 2000~2003 Period

Due to the data availability, the emission change pattern during the period of 2000~2003 was computed only for Korea. In this period, Korea's total emission elasticity was 0.7969, up from 0.457 during 1985~1990 period and 0.665 during 1990~2000 period. During 2000~2003 interval, the contribution from structural change was found to be -0.216 in elasticity, showing improvement from the previous periods. However, the contribution from technical change turned positive from negative. It recorded 0.0350 in elasticity term while it was -0.265 during 1985~1990 interval and -0.089 during 1990~2000 interval. This is a clear sign of deteriorating trend in the contribution of technical factors to the emission reduction in Korea. On the other hand, the structural factor contributed -0.216 in elasticity term in 2000~2003 interval.[7)]

4. Characteristics of Korea, UK, and USA in the Patterns of Emission Changes

It is remarkable that USA and UK are in the trend of declining total emission elasticity, though Korea alone is in increasing trend. UK is the best in terms of CO_2 emission reduction. USA's CO_2 emission elasticity was negative in 1980's but it was slightly positive in 1970's and 1990's. UK's emission elasticity in 1980's and 1990's were both negative. For most cases, structural factor and technical factor contributed to the reduction of the emissions, with the only exception of the technical factor

7) There are some data problems in estimating the figure for the change in the 2000~2003 interval. For the most recent data to be reported, data from National Statistical Office (Korea), instead of the IEA data, was used for the industrial data for the year 2003, However, there are some inconsistencies in the sectoral classification within the manufacturing sector between the two data sets. In particular, 'non-specified' subsector is problematic. If the figure for unspecified sector from the Korean NSO database is used as itself, which is quite small compared to the number for 2000 form the IEA data, the resulting number for the technical factor turns to be an extremely large positive number. So, we used a figure for the industrial production for 2003 obtained by extrapolation from the year 2000 data from IEA, instead of 2003 figure from Korean NSO. By these reasons, the 2000~2003 interval estimation should be interpreted with reservation. Hoverer, even after considering this data problem, it seems to be almost clear that there is a rising trend for the technical facor's contribution to the CO_2 emission increase for Korea.

during the 2000~2003 period for Korea. The sizes of structural factors are not very large for all countries.

5. International Comparison Regarding the Technical Factor

The major difference among the countries comes from the technical factor. For UK, technical factor plays important role both for the periods of 1980 to 1990 and 1990 to 2000. For USA, technical factor was weakened in the period of 1990 to 2000 compared to the previous period.

Compared to USA and UK, the contribution of technical factor to the reduction of emissions is the lowest for Korea. The elasticity for technically induced change was -0.265 for Korea, -0.960 for USA, and -0.713 for UK during 1980~1990, while it recorded as -0.089 for Korea, -0.799 for USA and -0.987 for UK during the period from 1990 to 2000. In the interval of 2000~2003, the contribution of technical factor to the emission change even turned to a *positive figure*, which means technical change induced CO_2 emission *increase, instead of reduction*, in Korea.

It can be inferred in two ways. Since the 'technique' is defined as the each subsector's emission coefficient. This emission coefficient is determined by the two elements. First one is the real technical change which brings up less emission from the same production level. Second one is the change in the composition of production items within each sub-sector. The result may be the combined one of these two elements. In other words, Korea has recently experienced intra-industry structural change towards CO_2 intensive one, or it has been deteriorated in CO_2 efficient technology.

Ⅳ. Conclusions and Implications

There are three observations. First one is that Korea's emission is increasing while USA and UK are experiencing reduction or stabilization of CO_2 emission in the manufacturing sector. Second observation is that technical factor in Korea does not contribute much to the reduction of CO_2 emissions and even showed deterioration in the 2000~2003 period. Third one, which is the combined result of the first and the second one, is that Korea's increasing trend in CO_2 emission is mainly due to the failure in technical progress or the failure in the improvement of the structure of subcategories within each sub-sector, or due to both causes.

The policy implications is clear. Based on the observations and analyses for the period from 1980 up to 2003, Korea's situation in the manufacturing sector is adverse in terms of climate change. Technical progress in the greenhouse gas saving area has been retarded or even worsened. Due to the China factor, Korea's traditional sectors such as iron and steel and petrochemicals are revived and even booming, giving little room for the climate friendly sectors and businesses to prosper. This is a very risky situation not only for the global climate but also for the Korean economy.

It is recommended that Korea should adopt firm, but market-oriented policies to revert these adverse trends. Without these policy initiatives, Korea may be confronted with unprecedented economic and environmental challenges in the near future.

◎ References ◎

1. Ang, B. W. and S. Y. Lee, "Decomposition of Industrial Energy Consumption: The Energy Coefficient Approach," *Energy Economics* 18, 1996, pp. 129～143.
2. Ang, B. W. and F. Q. Zhang, "A Survey of Index Decomposition Analysis in Energy and Environmental Studies," *Energy*, 25, 2000, pp. 1149～1176.
3 Ang, B. W., F. Q. Zhang and Ki-Hong Choi, "Factoring Changes in Energy and Environmental Indicators through Decomposition," *Energy* 23(6), 1998.
4. Choi, Ki-Hong, "An Application of Divisia Decomposition Analysis to the Measurement of Thermal Efficiency Improvement of Power Measurement," *Environmental and Resource Economics Review* 9(5), Korea Environmental Economics Association/Korea Resource Economics Association, December 2000 (in Korean).
5. Chung, Hae-Sick and Kiehoon Lee, "Decomposition of Energy-induced CO_2 Emissions in Korea Using Log Mean Divisia Index Approach," *Environmental and Resource Economics Review*, Association, 10(4), Korea Environmental Economics Association/ Korea Resource Economics Association, December 2001, pp. 569～589 (in Korean).
6. Greening, Lorna A., William B. Davis, Lee Schipper and Marta Khrushch, "Comparison of Six Decomposition Methods: Application to Aggregate Energy Intensity for Manufacturing in 10 OECD Countries," *Energy Economics* 19, 1997, pp. 375～390.
7. Han, Taek-Whan and Wonzoe Shin, "A Note on the Residual Problem in the Decomposition Technique in CO_2/Energy Studies," *Social Science Review*, vol. 22, Social Science Research Institute, Seo-Kyeong University, 2005 (in Korean).
8. IEA, *Energy Balances of OECD Countries*.
9. IEA, *Energy Statistics of OECD Countries*.
10. Lee, Kihoon and Wankeun Oh, "Analysis of CO_2 Emissions In Apec Countries: A Time-series and a Cross-Sectional Decomposition using the log Mean Divisia Methid," *Energy Policy* 34(17), 2006, pp. 2279～2787.

11. Lenzen, Manfred, "Decomposition Analysis and the Mean-rate-of-change Index" *Applied Energy*, vol. 83, 2006, pp. 185～198.

12. OECD, *Industrial Statistics* (from website)

13. Oh, Jyn-Gyu, *Study on the Strategy for Sustainable Development in Korean Energy Sector*, KEEI, 2003 (in Korean).

14. Polenske, K. and X. Lin, "Conserving Energy to Reduce Carbon Dioxide Emission in China," *Structural Change and Economic Dynamics*, vol. 2, 1993.

15. Rose, A. and S. Caser, "Input-output Structural Decomposition Analysis: A Critical Appraisal" *Economic System Research*, vol. 8, 1996, pp. 33～62.

16. Schipper, Lee, Fridtjof Unander, C. Marie-Lilliu and Michael Landwehr, "The IEA Energy Indicators Effort: Applications on the Road from Kyoto," Workshop on Best Practices in Policies and Measures, 11-13 April 2000, Copenhagen.

17. Unander, Fridtjof, "Decomposition of Manufacturing Energy-use in IEA Countries, How do Recent Developments Compare with Historical Long-Term Trends?," *Applied Energy*, vol. 84, 2007, pp. 771～780.

요 약

제조업 부문의 이산화탄소 배출 요인분해:

한국 · 영국 · 미국의 국제비교 연구

한 택 환

본 논문은 로그 평균을 가중치로 이용한 디비지아 기법(LMWDM)을 이용하여 한국과 미국 그리고 영국의 제조업 분야에 있어서 CO_2 배출량의 변동에 대한 요인분해를 하고 이 결과를 분석하여 그 정책적 의미를 제시하고자 하였다. 이들 국가의 제조업에서 배출하는 CO_2량의 변화를 생산량의 변화, 구조적 변화, 그리고 기술적 변화라는 요인들로 분해하여 각각의 값을 비교하고 분석한 내용을 기록하였다.

분석결과는 크게 세 가지로 나누어 볼 수 있는데, 그 첫 번째는 한국제조업의 총 CO_2 배출량은 대상기간 동안에 꾸준히 증가해 오고 있는 반면에 미국이나 영국의 제조업분야에서의 CO_2배출량은 감소해 오거나 적정한 배출량 관리를 유지해 오고 있다는 것이다. 두 번째로는, 비교 대상국인 미국이나 영국에 비해 한국의 제조업에서의 CO_2 배출량 감소에 대한 기술적 요인의 기여도가 상대적으로 너무 작다는 것이다. 더욱이 미국이나 영국에서는 기술적 요인이 주효하여 CO_2 배출량을 줄이는 데에 크게 기여하였지만, 한국 상황은 기술적 요인이 CO_2 배출량을 저감하는 요인이 적었을 뿐 아니라 근년에는 오히려 배출량을 증가시키는 요인으로 작용하기도 하였다. 마지막으로는 앞의 두 가지 해석에 바탕을 두고 있는 것으로, 분석 대상 기간 동안의 한국의 CO_2 배출량의 증가는 CO_2 배출의 저감을 위한 기술진보가 미미하였기 때문이거나 제조업의 각 업종내의 세분류별 구조의 변동이 CO_2 배출량을 증가시키는 방향으로 전환이 상당히 일어났기 때문으로 보인다.

이에 대한 정책적 제안은 명백하다. 우리나라에서 CO_2 발생량을 저감하기 위한 노력이 전 산업에 걸쳐 이루어져야 할 것이고, 특히 저감기술 발전을 위한 투자와 에너지 저소비 산업으로의 구조변동을 유도하는 정책이 필요하다고 하겠다.

주제어: 로그 평균 디비지아 방법(LMWDM), 요인분해, 이산화탄소, 배출량, 제조업부문, 국제 비교, 한국, 영국, 미국

Decomposition of CO_2 Emissions in the Manufacturing Sector: An International Comparative Study for Korea, UK, and USA

Taek Whan Han and Wonzoe Shin

This paper draws some implications from Logarithmic Mean Weight Divisia Method (LMWDM) on the sources of CO_2 emission changes in the manufacturing sectors of Korea, UK, and USA. The sources of change in industrial CO_2 emission of a country, as manifested by production scale factor, structural factor, and technical factor, summarizes the forces behind the change in CO_2 emissions in each country's manufacturing sector.

There are three observations. First one is that Korea's emission is increasing while USA and UK are experiencing reduction or stabilization of CO_2 emission in the manufacturing sector. Second implication is that the technical factor affecting CO_2 emission in Korea does not help much, or even hinder, the reduction of CO_2 emissions, comparing to USA and UK. Third one, which is the combined result of the first and the second one, is that Korea's increasing trend in aggregate CO_2 emission throughout the periods in consideration is mainly due to the failure in technical progress, or the deterioration in the structure of within subcategories, or both.

The policy implications is clear. The obvious prescription is to launch a nation-wide policy drive which can revert these adverse trends.

Keywords: Logarithmic Mean Weight Divisia Method (LMWDM), decomposition, CO_2, emission, manufacturing sector, international comparison, Korea, UK, USA