H-2.2 Framing the Transition Interaction Model Related to Population and Global Environment

Contact Person Kenji Hayashi
Director
Dept. of Demography and Public Health, The Inst. of Public Health
Ministry of Health and Welfare
4-6-1 Shirokanedai, Minato-Ku, Tokyo 108, Japan
Phone +81-3-3441-7111(Ext.234), Fax +81-3-3446-9247

Total Budget for FY1994-FY1996 15,098,000 Yen(FY1996／4,587,000 Yen)

Abstract

Total amount of green house gas from the economic activities is the product of cosumption of energy per capita and population. Considering the poppulation size as well as the potential of economic development in China, the country would play the key role in terms of global warming.

In the present study, the impact of population increase on total CO_2 emission in China during 1982-1990 period was analyzed. During the study period, population increase and CO_2 emission per capita contributed 21% and 70 % respectively. In terms of population increase by region, some provinces in inland area and megacities like Shanghai and Beijing contributed most. For CO_2 emission per capita, north-eastern provinces and south-eastern provinces along the coast are remarkable. Estimate of total emission of CO_2 by 2010 will amounts to 1.6 million tons, 74 % increase related to 1992. Energy transition is the key for stabilization of CO_2 emission in China.

Key Words Carbon Dioxide, China, Economic Growth, Global Warming, Demographic Transition

1. Introduction

Environment protection as well as population control will have become more important issues human has to tackle towards the 21st century. A series of international conferences presumed that population increase may accelerate the massive consumption of natural resources resulting in serious environmental destruction. Agenda 21 which is action plan subject to " Rio Declaration " on the Earth Summit in 1992 placed emphasis on demographic factor for solving environmental issues and called for international cooperative efforts.

Among various environmental issues, global warming above all has highlighted international conferences mainly because every country more or less shares the responsibility and its consequence as well. Although scientific evidences to prove mechanism of warming have not sufficiently collected so far, temperature rise has been traced for many years(1).

Scientists manifested various kinds of gas play the vital role in global warming, which are known as " the greenhouse gases ". Among greenhouse gases, carbon dioxide is estimated contributing more than 50% to global warming(1). Considering the population size as well as the potential of economic growth in China, the country would play the key role in terms of global warming and therefore is a case in point to study the demographic impact on CO_2 emission.

2. Research Objective

In the present study, the impact of population increase on total CO_2 emission in China during 1982-1990 period was analyzed. With Bongaarts method the relationship between industrial transition and demographic transition was explored. The apporoach is intended to provide the information which may sugge st the direction of population and environment control policy.

3. Materials and method

In the present study, the Bongaarts model was applied to the period from 1982 to 1990 . According to Bongaarts, total emission of greenhouse gas can be simply divided into two components, population factor and non-population factor. Those are population size and energy induced carbon dioxide per capita which derives from economic activities. Proportional contribution of both components to CO_2 gain between time points can be algebraically computed(2).

To be specific about the model, total CO_2 emission can be decomposed into five components as follows(Fig 1):

The product of population size and GDP per capita make up economic output and this subsequently produces enegy consumption by multiplying energy intensity. The definition of energy intensity is given by the primary energy supply per unit currency which implies the degree of energyconservation or efficient utilization of energy.

Carbon emission rate from fossil fuels can be obtained by the product of energy consumption and carbon intensity. Carbon intensity is defined by carbon emission per unit of energy consumption . Lastly, deforestation should be taken into account to output total carbon emission rate in industries. Since fuelwood for local use mostly fails to be included in governmental statistics unless the fuel is on commercial basis, it is hard to estimate the extent of deforestation. Therefore, deforestation will be neglected in the present analysis although the assesment has become possible these days by means of satellite sensing.

Fig 1 Bongaarts method

$$\text{Total } CO_2 = P \times CO_2/P$$
$$\text{Total } CO_2 = P \times GDP/P \times E/GDP \times C/E + D$$

P : Population   GDP : Gross Domestic Product
E : Primary Energy Supply
C : CO_2 emission by various sources of fossil fuels
D : Deforestation
E/GDP : Energy Intensity   C/E : Carbon Intensity

In order to see the perspective of CO_2 emission in the future, demographic transition as well as economic growth deserve attention. For demographic transition, Cho proposed an index which contains fertility, mortality and urbanization factor(3). Demographic transition index including its components take the valué between 0 and 1, the higher the value, the closer the transition level completed(See appendix).

Since urbanization is not contained in demographic transition theory, demographic transition index itself was not taken into account to examine the relationship among various parameters related to CO_2 emission. The definition of urban area has changed a couple of times in the last 15 years in China. For this reason, proportion of non-agricultural population was used for the corresponding index.

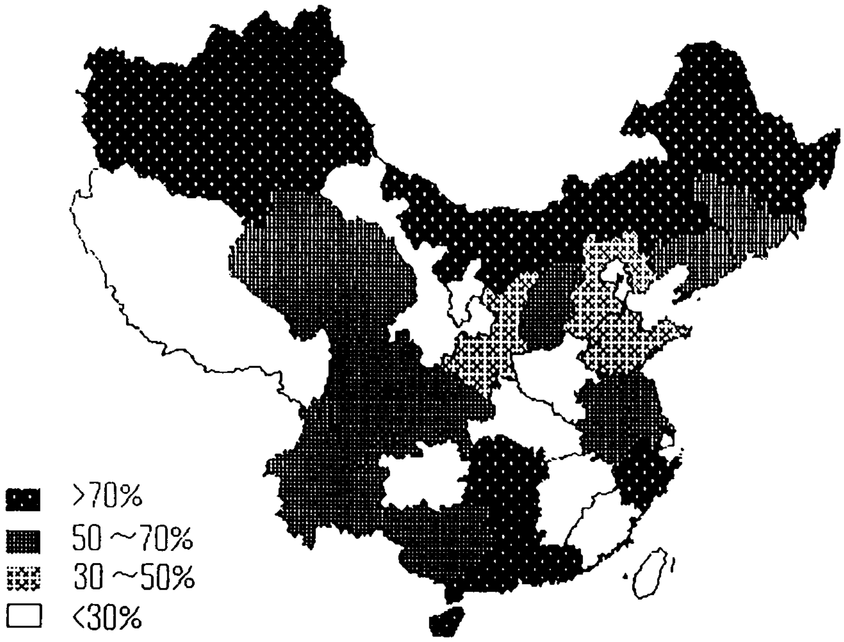
The data source for the analysis in the present study was drawn from Annual Almanac of China's Population(4), China Statistical Year Book(5), UN Demographic Year Book(6) and China Environment Year book(7).

4. Results

During the study period, population has increased from 1.01 to 1.14 billion, one hundred and thirty million increase, corresponding to 13% of population in 1982, while energy consumption has increased from 62 to 98 billion tons on standard coal basis, that is 58% increase. Converting a variety of fossil fuels consumed into the quantity of CO_2 emitted, it has

By decomposition method it is estimated the population factor, that is population increase, contributed 21% and non-population factor, that is CO_2 emission per capita contributed 70% respectively during the period. Separating the period at 1986, population factor increase its weight in the latter-half. However, non-population factor which includes GDP per capita, energy intensity and carbon intensity obviously overweigh the population factor through(Table 1).

Fig 3 Percentage Contribution of CO_2/P to Total CO_2 Emission by Province(1987-90)



Looking at economic growth , substantial GDP per capita has increased steadily since 1983 and accelerated its velocity in 1987. During the period it has substantially increased 1.6 times. Energy intensity has increased from the scratch until 1987 and turned downwards thereafter. For carbon intensity, it has kept stable through the period.

In terms of population factor contributing to CO_2 emission by region, some provinces in inland area and mega-cities like Shanghai and Beijing contributed most(Fig 2). For non-population factor, that is CO_2 emission per capita, north-boardering and south-eastern provinces along the coast are remarkable(Fig 3).

increased from 400 million tons to 600 million tons, 50% increase.

Table 1 Percentage Contribution of Population and Non-Population Factor to CO_2 Gain

Duration	% contributed by population	% contributed by CO_2/P	Residual(%)	Total
1982-'90	20.9	70.4	8.8	100 %
1982-'87	18.5	75.8	5.7	100 %
1987-'90	34.0	63.1	2.9	100 %

Fig 2 Percentage Contribution of Population size to Total CO2 Emission by Province(1987-90)

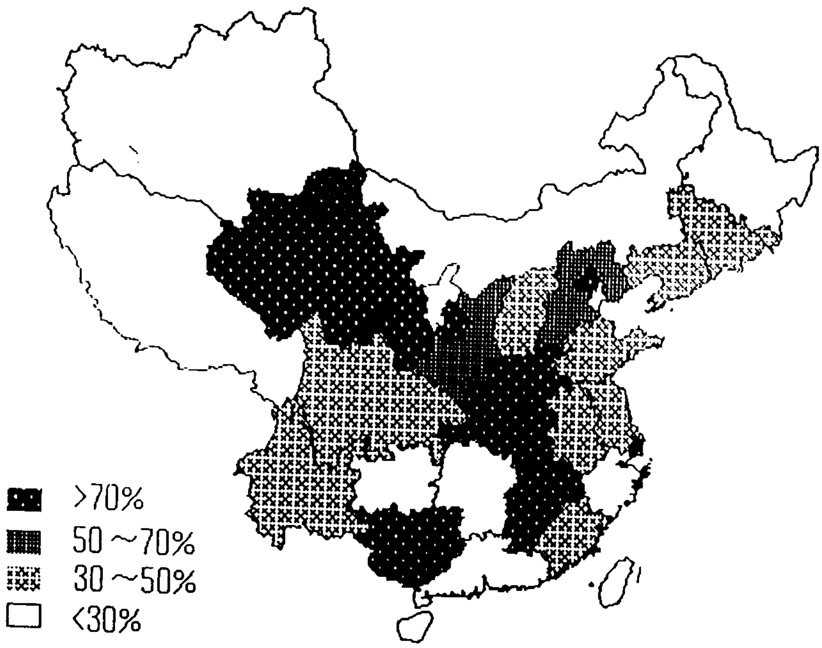


Table 2 Demographic Transition Level by Province in 1990

	Demographic Transition Level(Index)	Fertility Transition Level	Health Transition Level	Urbanization Transition Level
Beijing	0.99	0.99	0.97	0.69
Tianjin	0.96	0.94	0.95	0.72
Heibei	0.85	0.83	0.93	0.42
Shanxi	0.84	0.81	0.87	0.57
Nei Monggol	0.84	0.89	0.81	0.49
Liaoning	0.96	0.97	0.90	0.72
Jilin	0.91	0.92	0.85	0.72
Heilongjiang	0.91	0.93	0.84	0.67
Shanghai	1.00	0.99	1.01	0.64
Jiangsu	0.90	0.89	0.94	0.52
Zhejiang	0.96	0.98	0.94	0.63
Anhui	0.80	0.80	0.88	0.34
Fujian	0.85	0.83	0.89	0.51
Jiangxi	0.78	0.81	0.81	0.36
Shandong	0.90	0.87	0.91	0.62
Henan	0.77	0.74	0.89	0.34
Hubei	0.86	0.81	0.83	0.73
Hunan	0.80	0.82	0.82	0.43
Guangdong	0.93	0.80	0.95	0.87
Guangxi	0.80	0.77	0.87	0.44
Sichuan	0.82	0.93	0.82	0.32
Guizhou	0.71	0.73	0.77	0.31
Yunnan	0.75	0.79	0.74	0.41
Shaanxi	0.79	0.77	0.85	0.44
Gansu	0.80	0.83	0.83	0.40
Qinghai	0.73	0.81	0.69	0.34
Ninxia	0.78	0.79	0.84	0.38
Xinjiang	0.72	0.70	0.77	0.43
MEAN	0.85	0.85	0.86	0.52
S D	0.085	0.082	0.073	0.157

As shown in the table, costal provinces including mega-cities has almost completed its demographic transition as developed countries(Table 2). Most provinces in inland area also has achieved middle level of transition. These provinces even enjoy high level of fertility and health transition. The descrepancy among provinces is mainly due to urbanization level.

In correlation analysis, fertility and health transition level is strongly associated with proportion of non-agricultural population throgh which indirecly related to GDP per capita, the index of economic performance. Further more, carbon emission per capita mainly results from economic performance and energy efficiency.

Multiple regression analysis showed GDP percapita and energy intensity are only parameters predictive of CO2 per capita for a targetted province. The statistics of multiple correlation coefficient amounts to 0.94 with only two parameters mentioned above.

According to Chinese government, economic achievement will be fourfolds of 1980 by 2000 and double of 2000 by 2010. Energy consumption will be curbed within double of 1980 by 2000. Based on goverment policy, Chinese Institute of Energy Research released the perspective of energy demand planning to increase energy from hydropower and nuclear power.

Based on figures provided, total emission of CO2 will be 1.6 million tons by 2010, 74 % increase related to 1992. Now that population is projected to 13 to 22% increase by UN in the corresponding period, CO2 per capita will range from 42 to 54 % increase related to 1992.

5. Discussion

Concerning method of analysis of population impact on CO2 emission, Ehric provided a conceptual formula for greenhouse warming as a function of population growth, I = PAT. That is, Impact is the products of Population, Affluence and Technology. To be specific, total emission of carbon dioxide is the products of quantity of CO2 controlled by technology, degree of technology distribution and population size(8). The concept is instructive indeed, but is not practical unfortunately for estimation.

Edmonds and Reily developed a model which allows to compute the amount of CO2 emission with parameters including population size, economic indices, energy demand and supply, backstop technology and limits of resources. The model projected population and CO2 emission by 2075(9). Population is estimated to be more than double in most of developing regions and CO2 emission would inflate to eight or twelve times in the region under planned economy. However, the model intends a regional estimate so that it is not well-fitted for a country estimate.

The results obtained with Bongaarts model suggested the rapid growth of the second industry by early 1980s gave way to the tertiary industry after 1987. The plateau status of carbon intensity implies energy transition has not taken place so far. According to the statistics reported by Chinese Institute of Energy Research, coal still stands at 75% out of total energy consumed in 1992.

Discussing demographic impact on regional CO2 emission during 1987 to 1990 period, mega-cities were likely to subject to migration, so called " tide of working people ", from inland areas and inland areas are seemingly subject to natural increase on the other hand. The natural increase in inland areas is partly due to birth cohort of early 1960s, which is baby boomer generation, entering marriage age by the time.

Since non-population factor is a comprehensive indicator, regional variation of GDP per capita, enrgy intensity and carbon intensity should be observed. Although the results were not described in detail in the present study, their regional variations suggested industrial transition along with energy transition are the key to stabilization of CO2 emission in China.

Finally, the authors would like to illustrate energy demand by sector according to developmental stage(10). The concept is useful to focus the target consuming quantity of energy. In the take off stage, energy demand rises in pace with industrialization as observed in early 1980s in China.

Remarkable increase of energy for transporting goods or raw materials foll ows due to expantion of production and sales. The stage was also observed in late 1980s in China. In the third stage, energy consuming household appliances become popular as standard of living improves, which then triggers the energy demand for livelihood use.

In the fourth stage, national affluence provides people with more opprtunities to travel around. Increasing public transport for passengers and automobiles for private use demand another peak of energy consumption. After getting into fourth stage, the tertiary industry features national economy. It will be safe to say that the current China is in the transition period from third to fourth stage.

In summary, although the natural increase rate has achieved satisfactory level in China as a whole, considerable population increase will be expected due to its huge population size. From demographic point of view, natural increase in inland area and social increase in mega-cities will play important role in stabilization of total CO2 emission. Since economy is expected to keep growing towards 21st century in China, the key to stabilization of CO2 emission per capita is industrial restructure as well as energy transition accompanying introduction of clean technology.

6. References

1. Bates AK Climate in crisis. Summertown: The Book Publishing company. 1989: 5-24.
2. Bongarrts J. Population growth and global warming. Population and Development Review 1992; 18(2): 299-319.
3. Cho LJ. Industrial transition and demographic dynamics of the Asia-Pacific region. Proceeding of the international symposium on the role of the Asia-Pacific region in world economic development 1984(Tokyo); 41-59
4. China Academy of Social Science, Population Research Institute. Almanac of China's Population : 1985, 1986, 1992. Beijing : Economic Management Publishing Co.
5. State Statistical Bureau, People's Republic of China. China Statistical Year book : 1982-1995. Beijing : China Statistical Publishing House.
6. United Nations Statistical Bureau. Demographic Year Book : 1980-1990. New York
7. China Environment Year book Committee. China Environment Year book : 1995. Beijing : China Environment Year book Press.
8. Ehric PR and Holdren JP. Impact of population growth. Science 1971; 171: 1212-1217.
9. Edmonds J and Reilly J. A long-term global energy-economic model of carbon dioxide release from fossil fuel use. Energy Economics 1983; Apr. 74-88.
10. Tomidate T and Kibune H. Entrance to energy economics. Tokyo : Touyou-Keizai- Shinpou, 1994: 17(in Japanese)

7. Appendix

Demographic Transition Index

Cho L.J. combines fertility, mortality and urbanization factor into single index to assess the level of demographic transition in a certain region.

Demographic Transition Index =

$$0.40\ [\ (7.5 - TFR)\ /6.2\ ]_{(1)} + 0.4\ [\ 1 - (7.5 - e0)\ /4.3\ ]_{(2)} + 0.2\ [\ U\ ]_{(3)}$$

TFR : Total Fertility Rate   e0 : Life Expectancy at Birth

U : Proportion Urbanized

(1) : Fertility Transition Level
(2) : Health Transition Level
(3) : Urbanization Transition Level

TFR represents total fertility rate, e0, life expectancy at birth and U, percent of poppulation urban respectively. For the first term in equation, maximum TFR was assumed to be 7.5 and minimum 1.3. To standardize the value , the difference (7.5 - TFR) was divided by the maximum possible change 6.2. Maximum and minimum life expectancies were calculated using the maximum 75 and minimum 43 figures for e0 in UN; Demographic Year Book. Again, to stadardize the value, the difference(75 - e0) was divided by the maximam possible change 43.

Each term on the right hand without coefficient represents , Fertility Transition level, Health Transition level and Urbanization Transition level completed. All of the indicators take the value between 0 and 1, the higher the value, the closer the transition level completed.