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Climate Change: The Empirical Study of the Sensitivity Model in China's Energy Efficiency and Sustainable Development

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Abstract: *In the evolution of CO_2 emission intensity, population, total CO_2 emission, annual GDP growth, and emission per unit energy index is mainly an empirical issue that cannot resolve with uncertainty from the experience of a group of countries at any given period. The current research work considered 32 variables including Climatic, Anthropogenic and Greenhouse gases effects as it affects energy efficiency and sustainable development in China from year 2007 - 2014. The study employed Sensitivity Model Prof. Vester which had a recursive structure of the nine steps thus establishing linkage between greenhouse gases effect and climate change in China so as to evaluate a sustainable indicator in greenhouse gases and change effects. The sensitivity model had system tool that can be directly activated by clicking the recursive buttons which possesses mediative capacity as a major feature. The results of the impact matrix have high numerical values showing how critical these coefficient variables are to the entire system ranging from highly critical to not critical. Value 2035 for Population represent Highly Critical variable, while 1530, 1435, 1332, 1260, 1184, and 1170 represent critical variables for the Total amount of CO_2 emission, Annual GDP growth, Emission per unit energy, Emission intensity, CO_2 per capita emission, and Carbon intensity of energy use, in that order respectively. These are the seven most important variables that accounted for climate change in China among which population is the key factor linking other variables to affect climate change in China.*

Keywords: *CO_2 emission, emission intensity, global climate change, round/year sensitivity model, variability*

INTRODUCTION AND BACKGROUND

Future levels of global greenhouse gas (GHG) emissions are the products of a very complex and ill-mispresented dynamic system driven by socio-economic development, population growth and technological progress forces. Many models are applicability of reality and some have specific application of a frequently used approach to organize discussion of the drivers of emissions through the so-called IPAT identity that relates impacts (I), population (P), multiplied by affluence (A) and technology (T). However, the driving forces might be different for some species of anthropogenic emissions (Kaya, 1990; Yamaji et al., 1991). Thus, it becomes virtually impossible to predict emissions accurately and in many cases making it a tasking exercise hence, the need for modelling. Today, numerous factors influenced future emission paths in the world and these factors are clearly, demographic and economic developments that play crucial role in determining emissions. However, many other factors are also involved, from human resources (education, institutional frameworks, and lifestyles) to technologic change, natural resource endowments, and international trade. Intergovernmental Panel on Climate Change 2001 concludes that: "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to anthropogenic activities." According to Bodansky (1994), humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war. He went to demonstrate that the climate system is an angry beast and we are poking at it with sticks!

Addressing climate change requires two complementary actions: reducing/mitigating greenhouse gas emissions and adapting to climate change

These GHG emissions are on the increase, the resultant effects are visible for all to see, and the business as usual in the political setting is/are not helping matters hence the aftermath of the impending dangers with regards to present status are imminent, and poses great dangers to the future generation. Scientist have to provide the world with working scenarios on which to act upon hence emissions scenarios via sensitivity model will provide an important input for the assessment of future climate change, hence the need for this research.

Background

The overall objectives of this research framework are to look at the Concept of Mitigative and Adaptive Capacity with the view of ameliorating the already degrading climatic situation in some developing countries, with specific reference to China whose CH_4 and CO_2 emissions are second to none. Also to be able to capture the system using fuzzy logic which provides information about the regulatory cycles, feedback loops, critical or reactive areas, limits, through partial scenarios and simulation and bringing to light how capable a system is to sustainable development. Capability, generally, refers to the ability of individuals, institutions, governments, and other entities to perform functions, solve problems, and achieve objectives (UNDP 1997). In the context of the Convention, "capability" might refer to a country's ability to "protect the climate system." Assessing a country's capability to mitigate climate change is obviously a complex and multifaceted undertaking.

The primary purpose of this study is to provide a comparative baseline analysis of the change in anthropogenic emissions of a large number of countries that can serve as a starting point for detailed country by country investigation, and to provide focus on the key factors that are amenable to policy interventions.

The principal tool for describing the relationship between the growth of emissions and changes in various related factors might have "Cybernetic relationship using the Sensitivity Model". Although there is substantial literature such as Environmental Kuznet Curve (EKC) that applies other technique to fossil fuel emissions of CO_2, much of this concentrates on high income countries, with one or two large developing countries also being covered. Studies covering a slightly wider range of countries have used data from 2002 or older so recent important developments are not reflected in these studies.

The assessment of climate change dictates a universal perspective and very long-time horizon that covers periods of at least a century. China adopted and still adopting EU standards for pollution emissions from cars with an approximately 8 to 10 years lag as investigated by Gallagher (2003) and had reduced sulphur emissions and even carbon emissions in recent years (Diesendorf, 2003). Gallagher while concurring with Diesendorf (2003), observed that ambient air pollution has been reduced in several major cities and brought sustainable development, however, the gloom over China's environment may be overstated. China is an ideal test case of the controversial idea of the Environmental Kuznet Curve "EKC," according to which economic growth precedes environmental improvement. Although current environmental trends in China are serious and deteriorating in many areas, some unappreciated signs of improvement are also appearing.

Growth in emission according Wang et al. (2005) and Baumert et al. (2006) agreed that the change in economic policy in 1979 and the changing fuel mix have helped to reduced energy intensity which help to halt this emission growth but Gross Domestic Product (GDP) and population effect outweighed these in all cases. Finally, Liu and Ang (2007) reviewed a large number of studies using various approaches such as decomposition analysis to discussed the effect of emission growth and draw out some of their strengths and weaknesses; thus, focused on energy use and CO_2 emissions, e.g., driving forces, state and responses influences development "Policies."

China continues to be the world's second largest energy consumer after the United States, and its impact on the global energy economy will likely remain strong in the coming decades. According to the International Energy Outlook (2015), China consumed 20% less energy than the United States in 2004 but is expected to consume 21% more by 2030. By the year 2030, China's energy use is projected to be dominated by coal (65%), oil (22%), natural gas (6%), renewable (5%), and nuclear power (2%) by if the present business as usual scenarios continue unabated. In United States as well as in China the transportation sector, dominated oil use. It is estimated that by 2030, 47% and 42% of China's oil use will be for transport and industry respectively.

Coal will remain the dominant fuel in China through 2030, with its use concentrated in the industrial and electric power sectors. Consequently, China will remain the world's largest producer and consumer of coal. In the electric power sector, China's use of coal is projected to grow at an average rate of 3.5% per year between 2004 and 2030 (IEA, 2005). In China, in the year 2004 to 2030, electricity generation from nuclear power is projected to grow at an average annual rate of 7.7%. Thirty six gigawatts of the projected 58 gigawatts in the of additional installed nuclear generating capacity projected in the developing economies of Asia is consumed in China. With this heavy reliance on fossil fuel, China will continue to have a major impact on the global environment.as it has now become the manufacturing base of the world. By 2030, energy-related CO_2 emission in particular are projected to grow by 26% of the world total while 3.3% annually Coal-related emissions are projected to grow at the same period. By 2030, China's projected total coal-related emission will rise to 48% of the total worldwide (IEA, 2005).

Clearly, it has shown that while some research being carried out in China has been done in isolation to single or combined variable factors, none has been so robust, interactive, and comprehensive as the sensitivity model (SM), which also gives room for intervention at certain periods for better policy implementation and sustainable development. As the prediction of future anthropogenic GHG is becoming impossible, alternative GHG emissions scenarios, such as SM, have become a major tool for the analysis of potential long-range developments of the socio-economic system and corresponding emission sources. 'The sensitivity model provided a suitable approach for modeling interlocking repercussions of climatic change and natural disaster. In contrast to alternative approaches, it offers a special advantage: its cybernetic methodology takes account of the holistic character of systemic structures and means non-quantifiable factors (risk perception, the quality of the natural landscape) can be modeled'.

Climate Change

In early June 2008, China unveiled the National Climate Change Program as part of China's obligation under the United Nations Framework Convention on Climate Change. Under the plan, China will use hydropower, nuclear energy, and biomass fuels and gas to help cut 950 million metric tons (CO_2 equivalent) per year of the greenhouse gas emission for 2010 upwards. Specifically, China expects development of hydropower resources to cut the emissions by 500 million tons by 2010, nuclear energy development to account for 50 million tons of reduction, biomass energy to help reduce emission by 30 million tons, and other renewable power generation (solar, wind, geothermal, and tidal energy) to reduce emissions by 60 million tons. Additionally, China expects more efficient thermal electricity production and transmission to reduce emissions by 110 million tons, and the re-use of coal-bed and coal-mine methane for electric power generation to lower them by 200 million tons (Sinton and Nathaniel, 2006).

China is the biggest producer and consumer of coal in the world. More than 70% of the total energy in China is produced by coal combustion. Despite investment into renewable and nuclear power, this heavy dependence on coal is expected to continue for the next 50 or more years. Overall, air pollution trends represent growing economic, ecological, and human health threats both within and outside China (CNSB, 2005). Some 300,000 to 400,000 people die prematurely in China every year due to respiratory illnesses triggered by air pollution. Coal burning in China emits 25% of global mercury and 12% of CO_2 and China's State Environmental Protection Agency estimates that nearly 200 cities in China fall short of the World Health Organization Standards for airborne particulates (CNSB, 2005)

Despite China's abundant coal resources, the country is actually experiencing a coal shortage, because demand increases fast enough to outpace supply (Mai, 2005). This demonstrates China's strong dependence on coal, and suggests that commitments to reduce the usage of coal can be seen as a threat to China's energy security. Improving energy efficiency, diversifying energy and reforestation can all be considered as so-called 'No Regret' options. The per capita energy consumption will probably match the current global average by 2020 (Harris and Hongyuan, 2005). Even though the Chinese government has ambitious goals for reducing energy substitution, coal will continue to be the dominating energy source. Urbanization, population increase, and economic growth are all factors that point in the direction of a continued increase in China's CO_2 emission in the years to come.

This work will implore the sensitive model path in identifying and fully proffer mitigating and adaptive methods of sustainable development with respect to alternative energy and administrative know how which is the core of this study.

Approach / Experimentation of Sensitivity Model

The study used logical, scientific understanding and prediction of a sensitivity model (SM) Prof. Vester, which is an integer tool in the assessment of climate change in China. It provides the role for intuition, analysis, and synthesis, and thus links the scientific understanding by taking advantage of it features. It aids the assessment of future climate change, impacts, vulnerabilities, adaptation, mitigation, and sustainable development. The discussion of major scenario driving forces herein is structured by considering the links from demography and the economy to resource use and emissions (Ojekunle et al., 2009). A frequently used approach to organize discussion of the drivers of emissions is through the so-called IPAT identity, equation (1).

Impact = Population × Affluence × Technology ... (1)

The IPAT identity has been widely discussed in analyses of energy-related carbon dioxide (CO_2) emissions (e.g., Ogawa, 1991, Parikh et al., 1991, Nakic´enovic et al., 1993, Parikh, 1994., Alcamo et al., 1995., Gaffin and O'Neill., 1997, Gürer and Ban., 1997, O'Neill et al., 2000, in which it is often referred to as the Kaya, (1990) identity, equation (2).

CO_2 Emissions = Population × (GDP/Population) × (Energy/GDP) × (CO_2 /Energy) .(2)

The IPAT identity states that environmental impacts (e.g., emissions) are the product of the level of population times affluence (income per capita, i.e. gross domestic product (GDP) divided by population) times the level of technology deployed (emissions per unit of income).

The technique of decomposition analysis

The decomposition of fossil fuel CO_2 emissions into related factors dates back to a series of studies undertaken in the 1980s, mainly at industry level for a single industrialized country. Kaya (1990) was influential in proposing an identity around which a decomposition of emissions related to four factors could be based:

CO_2 emissions from energy ≡ CO_2 emissions per unit of energy consumed
× Energy consumed per unit of GDP
× GDP per capita
× Population … (3)

This has subsequently been expanded to

CO_2 emissions from energy ≡ CO_2 emissions per unit of fossil fuel consumed
× Fossil fuel consumed per unit of energy consumed
× Energy consumed per unit of GDP
× GDP per capita
× Population ... (4)

These identities focus on CO_2 emissions from the combustion of fossil fuels (oil, gas and coal). Although these are identities that must always be satisfied by the data, and ***are not based on an estimated model of causal links between the variables***, the movements of the components provide an important guide to changes in factors influencing CO_2 emissions from energy use.

Because the variable of interest, emissions from the consumption of energy, is related to the product of several factors, the change in emissions cannot simply be expressed as the sum of absolute changes in the five factors. Various solutions to providing a satisfactory and complete decomposition of the changes in emissions, related to the sum of a measure of changes of the factors, have been reviewed by Ang (2004) and a widely used solution is based on the so called logarithmic mean Divisia index (LMDI 1) as explained by Ang (2005).

According to Lee and Oh (2006), equation (4) can be rewritten as follows

E = The amount of CO_2 emissions from the consumption of fossil fuel

FEC = The Amount of Fossil Fuel Consumption

TEC = The Total Primary Energy Consumption

GDP = Gross Domestic Product and

POP = Population.

Hence emissions in country i can be expressed as:

$E_i \equiv (E_i / FEC_i) \times (FEC_i / TEC_i) \times (TEC_i / GDP_i) \times (GDP_i / POP_i) \times (POP_i) \equiv C_i S_i I_i G_i P_i$ (5)

The change in a country's emissions (ΔE_i) between a base year 0 and an end year T can be decomposed into the effects of : (i) the change in C (the emissions per unit of fossil fuel, termed the coefficient effect, C_{eff}) ; (ii) the change in S (the share of fossil fuels in total energy, termed the substitution effect, S_{eff}); (iii) the change in E (the energy intensity effect, I_{eff}); (iv) the change in GDP per capita (G_{eff}); and (v) the change in population (P_{eff}).

$\Delta E_i \equiv E_i(T) - E_i(0) \equiv C_{eff} + S_{eff} + I_{eff} + G_{eff} + P_{eff}$ .... (6)

The effects, in turn, can be calculated from the following formula using LMDI[1]:

$C_{eff} = [E_i(T) - E_i(0)] \{ \ln [C_i(T) / C_i(0)] / \ln [E_i(T) / E_i(0)] \}$ ....(7)

Other effects ($S_{eff} I_{eff} G_{eff} P_{eff}$) can also be derived from similar formulae. Hence the formulae for the input basis for Sensitivity model

Handling Complexity with the Tool of the Sensitivity Model

The main menu of the sensitivity model shows the recursive structure of the nine steps of the system tool that can be directly activated by clicking the recursive buttons (figure 1).

Iterative Process of System Model Development

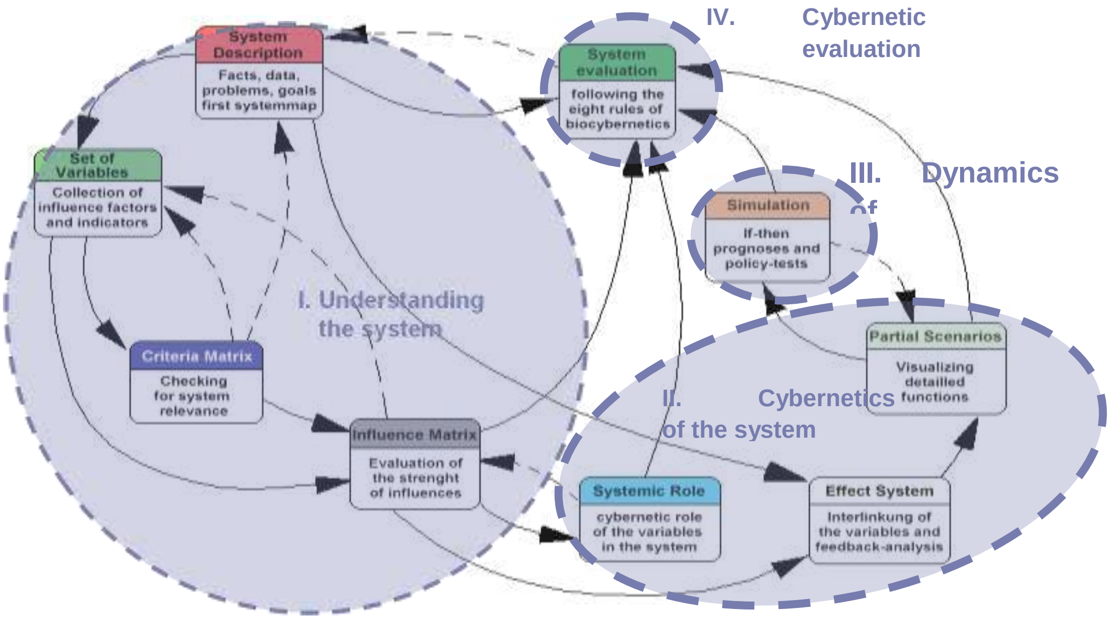

Figure 1: The 4 Sub-divided Iterative Process of System Model Development

RESULTS AND DISCUSSIONS

The Research study focused on 27 climatic related variables carefully observed and perfectly reflected in the case study with strong database and links that influenced climate change over the past years. The research restricted it findings to human anthropogenic emissions and considered the main driving force to these gas in relative to developing countries like China. However, a close reference especially to past climatic changes and economic development is been made in an attempt to ensure a robust analytical presentation. In order to arrive at the set of system-relevant variables that is needed for a meaningful, useful cybernetic model, (by cybernetic, it meant simply providing impulses towards self-regulation, 'touching off' interaction between individual and environment, stabilizing systems and environment through flexibility, making use of existing forces and energies, and constantly interacting with them (figure 2) while results for index of impact/influence and matrix of consensus (figure 3 and 4) respectively.

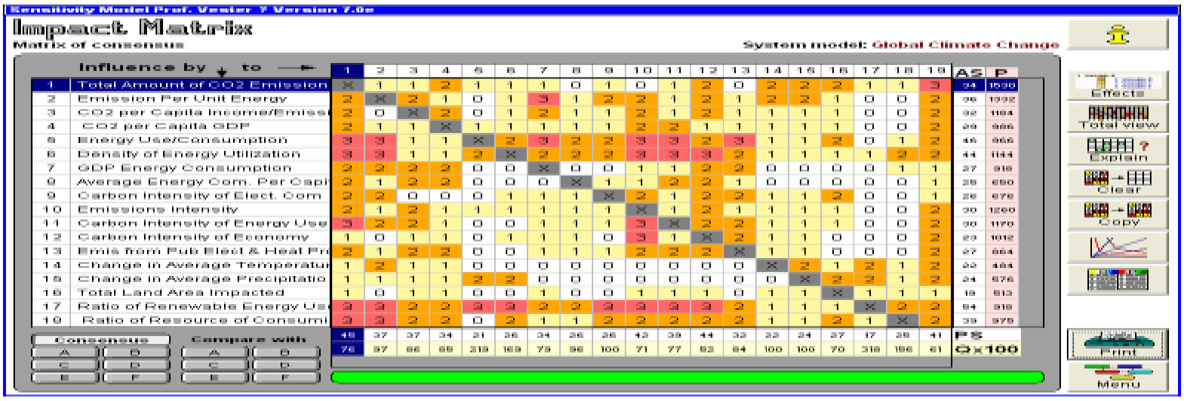

Figure 2. Impact Matrix of the 27 Variables Evaluated

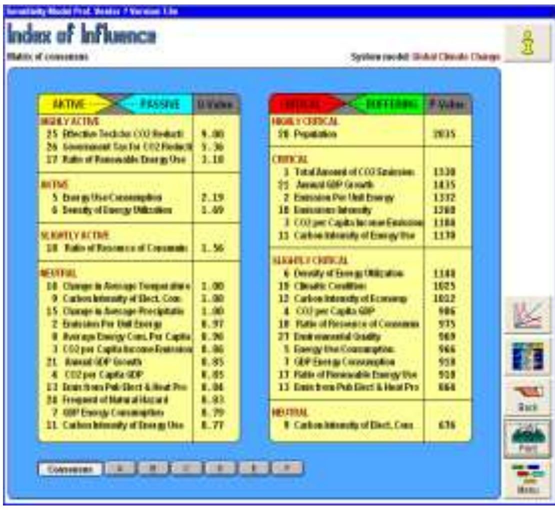

Figure 3. The Q and P Index of Influence of the Matrix of Consensus

Figure 4. The systemic Role distributing Various Variables as allocated within the four systems role of the Matrix of Consensus

[1] *The eight basics rules of bio-cybernetics*

The criterion of viability is based on eight rules; complying with these, coupled with interconnected thinking, helps to avoid planning errors. These basic rules, were first formulated in connection with UNESCO study a quarter of century ago, are not something invented but copied from nature, these rules are:

Rule 1: *Negative feedback must dominate over positive feedback-Positive feedback sets things in motion through self-reinforcement.*

Rule 2: *The functioning of the system must be independent of quantitative growth.*

Rule 3: *The system must operate in a function-oriented, not a product-oriented manner.* **Rule 4:** *Exploiting existing forces in accordance with the Ju-Jitsu principle rather than fighting against them with the boxing method:*

Rule 5: *Multiple uses of products, function and organisation structures*

Rule 6: *Recycling-Using circular processes to keep refuse and sewage 'in the loop'*

Rule 7: *Symbiosis-Reciprocal use of differences in kind through link-ups and exchange.*

Rule 8: *Biological design of products, processes, and forms of organisation through feedback planning*

Based on the eight rules of engagement, the following feedback were obtained (Table 1) and used to develop the partial scenario used to run the simulation model (figure 5)

Table 1: Negative and Positive Variables Feedbacks

Var. No	*Variable Names*	*Negative*	*Positive*	*Total*
20	Population	192	82	274
5	Energy Use/Consumption	173	73	246
10	Emissions Intensity	160	64	224
1	Total Amount of CO_2 Emission	160	64	224
27	Environmental Quality	142	63	205
25	Effective Tech for CO_2 Reduction	140	50	190
17	Ratio of Renewable Energy Use	112	41	153
21	Annual GDP Growth	120	22	142
24	Frequent of Natural Hazard	89	44	133
6	Density of Energy Utilization	81	32	113
2	Emission Per Unit Energy	80	32	112
26	Government Tax for CO_2 Reduction	70	25	95
19	Climatic Condition	69	24	93
8	Average Energy Com. Per Capita	56	21	77
23	Current GDP per Capita	55	16	71
12	Carbon Intensity of Economy	11	54	65
11	Carbon Intensity of Energy Use	7	54	61
9	Carbon Intensity of Elect. Com	7	54	61
13	Emission from Pub Elect & Heat Pro	7	54	61
22	Current GDP	20	10	30
4	CO_2 per Capita GDP	4	0	4
16	Total Land Area Impacted	1	3	4
3	CO_2 per Capita Income/Emission	1	1	2
7	GDP Energy Consumption	1	0	1
14	Change in Average Temperature	0	0	0
15	Change in Average Precipitation	0	0	0
18	Ratio of Resource of Consuming	0	0	0

[2] Simulation Model Runs

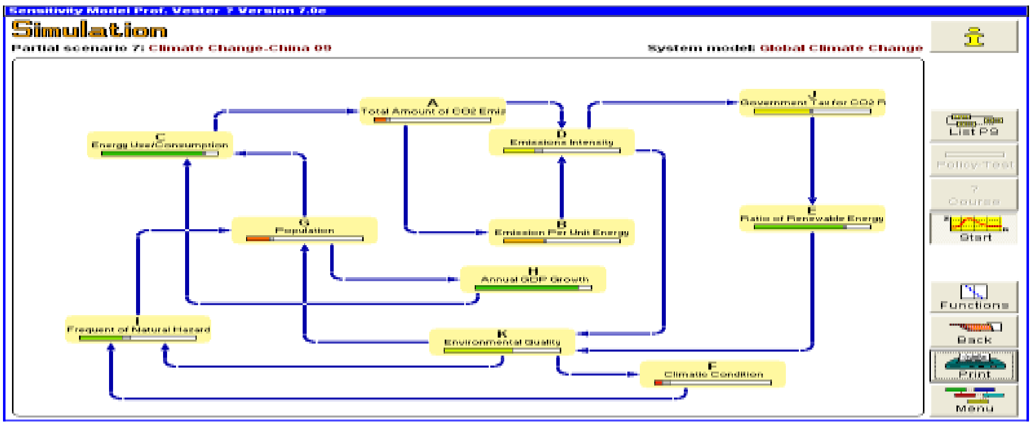

Figure 5: Simulation model being evaluated to some rounds

Mediation Capacity by Transparent Simulation
One of the main features of the model is its mediation capacity. New ways of visualizing the cybernetic behaviour of the system and its parts helps to put different interests in the same model showing their roles are a mutual influence in the complex pattern.

The impact matrix with high numerical values show how critical each variable is to the entire system, i.e., 2035 for Population (Highly Critical), while 1530, 1435, 1332, 1260, 1184, and 1170 represent critical variables for the Total amount of CO_2 emission, Annual GDP growth, Emission per unit energy, Emission intensity, CO_2 per capita emission, and Carbon intensity of energy use, in that order of magnitude respectively. These are the seven most important variables that accounted for climate change in China. These positions or criteria are entered into the systemic role, where each variable cybernetic is evaluated due to its interdependencies. Here, the system is distributed within the four fields of different variables. The model pattern of influence is encompassed at the four corners thus revealing the cybernetic role; these are a lever (Active), a risk factor (Critical), a measuring sensor (Reactive), an inert element (Buffering), and positions in-between. The feedback analysis of the effect system allows recognition of the dominant cycles of the seven critical impacts; these seven critical factors are placed at the centre of the effect system and controlling variables are interlinked together in a sustainable manner after serious consideration. The negative feedback in this case is the positive factors that are considered mostly for planning and modeling purposes (Frederic, 2007).

ANALYSIS AND FINDINGS

[3] Empirical Analysis and Application

Model estimations could incur heterogeneity bias—the confounding effect of unmeasured country-specific variables since these data set is pooled time-series of cross sections ones. It is likely that there are country-specific factors that might affect CO_2 emissions. For instance, the geographic location of countries may well be correlated with the level of CO_2 emissions. Many of the wealthier countries are located in the northern part of the globe where relatively more heating is needed.

Similarly, there are other factors shared by all countries in a given period that may vary across time. For example, the changes in emissions were affected by world energy prices and macroeconomic fluctuations. The ordinary least squares (OLS) estimation that ignores these problems could be biased and inefficient (Hsiao 1986). These descriptive analyses tend to suggest that the substantial increase in emissions could correlate for the last two decades with population growth as well as with growth in affluence although correlation could be different across the variable's groups. The population (r=0.61) and GDP per capita (r=0.42) are positively correlated with CO_2 emissions.

The role of population on emissions is the baseline model, with GDP per capita, population, and energy efficiency as the predictors and total emissions as the dependent variable. Both the dependent variable and predictors are all in natural logarithmic form. The model provides a good fit, with Akaike's information criterion statistic (AIC) equals – 1118 relative to 25 degree of freedom. The Durbin-watson (DW) statistic is in the neighborhood of 2, suggesting an absence of serial correlation of error terms (Greene, 1993). A positive association between population growth and emissions is confirmed; a one-percent increase in population raised the CO_2 emissions by 1.28%. In addition, a positive relationship between affluence and emissions is also confirmed; a one percentage increase in GDP per capita increased the CO_2 emissions by 1%. In contrast, an increase in energy efficiency could lead to a reduction of emissions: a one percent increase in energy efficiency reduced the emissions by 0.22%. The first order autocorrelation coefficient (AR1) is represented by rho.3

[4] The Role of Various Variables on Emissions and Others

The positive coefficient for *annual GDP growth* variable suggests that estimated emissions initially rise with *annual GDP growth*, and it eventually falls (as the quadratic term is negative (figure 6). However, the estimated turning point occurs at a very high out-of-sample income level, and this occurs almost for all critical variables on the 7th and 8th year (figure 6). In other words, within the sample data only a monotonically upward trend in total amount of CO_2 emissions, energy use/consumption, ratio of renewable energy use and emission per unit with increasing and harmonic income levels is discovered.

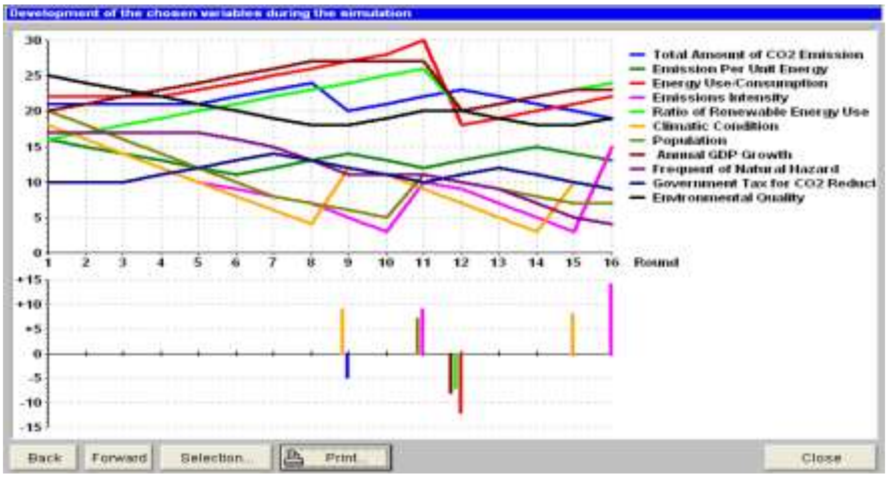

Figure 6: The simulation round (year) for 30 years with intervention
(Source: Author Simulation Model, 2010)

To check the robustness of out-of-sample income turning point, the study presents another specification in figure 6 where the emissions per capita are used as a dependent interconnected variable instead of the total emissions. This specification is similar to the log-linear specification that Holtz-Eakin and Selden, (1995) have used in estimating the presence of "Environmental Kuznets Curve". Model using emissions per capita as dependent variable also generates an out-of-sample income turning point at the 8th year steadying through the 12th year, although it is far less than the turning point at the upper peak with energy use/consumption hitting its limit of these variables under study in the simulation model. This confirms that substantial economic growth would be required before CO_2 emissions began to decline and the relationship between emissions and economic development is truly a linear one.

To further examine the relationship between population growth and emissions intensity, the model further introduce two more control variables, GDP per capita and frequency of natural hazard which are all the way declining until it reaches its lowest limit at the 11th year (figure 6). The variation of emissions across the trend could be affected by government tax for CO_2 reduction (Declining) and renewable energy use (Rising). Of course it is better to use government tax for CO_2 reduction (Declining) and renewable energy use (Rising) in the model, but the study may face some difficulties in the Sensitivity Model as some of the variables are not fully calibrated. Thus the increase percentage of annual GDP is used as a proxy to capture the possible linkage. The variation of emissions across variables could also be affected by the structural changes in the economy. The GDP per capital variable probably could not fully capture the variation in structural changes, and thus the study further introduce a variable, emission per unit energy with intercept annual GDP growth at the 15th year and increases with same rate as environmental quality which is the real indicator for sustainable development as well as showing the monotonic relationship between the two variables. The Sensitivity Model further confirms a positive and significant association between changes in population and changes in emissions intensity. Specifically, one percent increase in population will reduce the emissions intensity by 1.18%, which is slightly lower than that of baseline model. Thus, the impact of population growth on emissions is found to be robust.

[5] The Impact of Population Varies with the Levels of Affluence

To test the hypothesis that population pressure has exhibited different impacts on emissions across China with different levels of affluence, the study creates an interaction term on figure 6. This model is hierarchical to the baseline model, and these two models are nested. The model fits the data well, which is indicated by a further significant reduction of AIC statistic as compared with that of baseline model (-1187 verse -1118), relative to the change of 25 degree of freedom. The negative coefficient for the interaction term suggests that the marginal effect of population on emissions diminishes as income level stabilizes. In other word, the impact of population on emissions has been more pronounced in lower income than in higher income ranges.

The other appealing finding is the differentiating effects of energy efficiency on emissions in China at various affluence levels. The role of energy efficiency on emissions has been the greatest when the total amount of CO_2 emission is at its peak. A one percent increase in energy efficiency could decrease the CO_2 emissions by almost 1.5%, which is in sharp contrast to the 5th year when one percent increase in energy efficiency could increase the CO_2 emissions by almost the same one percent (figure 6). Also, at the lower middle-income range, a one percent increase in energy efficiency decrease the emissions by about half a percent while that of upper middle and high-income ranges, energy efficiency could only reduce the emissions by a little over 0.20%. Furthermore, affluence has exercised the greatest impact on emissions in low-income region; a one-percent growth in GDP per capita could bring about a 2.43% increase in emissions. It is the least in upper middle-income range where a one-percent growth in real GDP per capita increases the emissions by 0.51%.

As a result of the first intervention simulation (figure 7), while short time intervention for total amount of CO_2 emission in the 8th year, as well as Energy use/consumption, Annual GDP growth and Ratio of renewable energy use with the 11th year intervention would mean a long-term gain for the emission per unit energy and environmental quality. In the long term it would constitute a sustainable development to 20th year of prediction given the various interventions (figure 7), while all other things remain constant. Mounting social costs, loss of quality of life, neglect of local businesses as a result of orders economic policies, the disappearance of the associated alternative energy use for sake of poverty alleviation, and a lack of guarantee of provenance were among many consequences to be feared.

Other 'if-then' simulations with alternative possibilities then showed that things would develop differently if China Sensitivity Model variables did in fact start with higher Total CO_2 emission and population (Figure 7 and 8) but in returns for an additional guarantee of continued existence imposed certain controls.

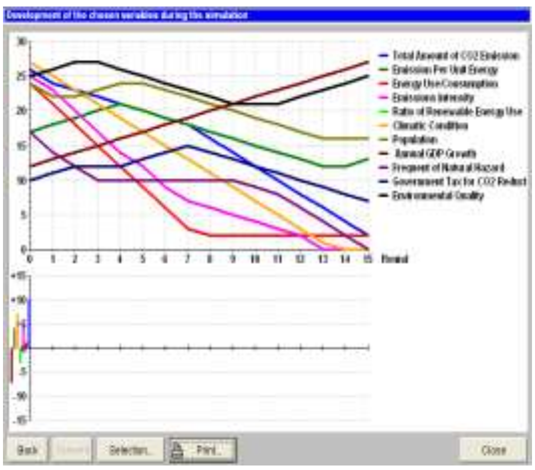

Fig 7: Showing higher starting points for CO_2 Emission and Population and lower GDP

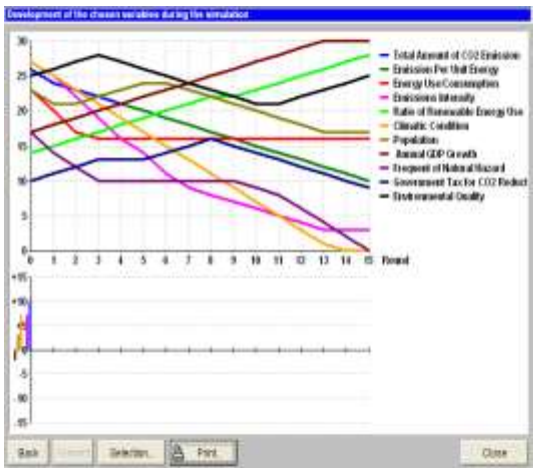

Fig 8: Showing higher starting points for CO_2 Emission, Population and GDP

The model may be too conservative since it gives too much weight to models with different starting point as shown above. Results suggest that a better model may have been reached as it possesses an even better sustainable intervening year for decision makers for the next 13-14 years smooth transition period. It shows that using the corrections of "if then" provided above (year 2009), it provides more realistic test results. While our universe of models includes simple reduced variable and time variants of models based on current reality, it would be an interesting future line of research to include forecasts from large scale flexible models, such as the SM model, into the universe of models which this study is currently pursuing into the required forecasts. Further this study worked on incorporating forecasts based on aggregate state level as well as other country aggregate emissions and test the behavior of the Reality Check with changing horizons.

The implication to this finding is such that the Chinese government must pay attention to these above listed 11 simulated variables listed above as well as some policy measures such as effective technology for CO_2 reduction and density of energy use, and most especially regulate population growth, seek advance technology for CO_2 reductions, improving green economy, also importantly, encouraging clean energy technology and focusing more on renewable energy even so much that China is blessed with vast area of land and sea. China is facing enormous challenge on poverty alleviation, and as a result will see rather focus on economic development rather than the deteriorating environmental quality. If this business as usual scenarios of pursuing economic development at the expense of environmental quality is not reversed, it will not only negate its economic prosperity but will affect global environment especially neighboring communities.

SUMMARY AND CONCLUSIONS

The empirical study confirms that Chinese economic growth with attendant rising average incomes (income per GDP) and population is by far the most important driver of energy trends and CO_2 emission with resultant effect to poor environmental management as the expense of economic drive hence making China's overall environment sustainability poor. Although its economy is big, due to its large population, it's per capita GDP though increasing is still relatively low. From a per capita perspective, CO_2 emission intensity is not high in China (compared to other developed country like US) since it calculated based on population number (per capital population) but in reality, China's total CO_2 emission will be considered high in absolute term which has great implication for China's high temperature and subsequent climate change. These empirical systems show that China has a long way to go in improving the country's environmental quality, and as such, in the course of its development, improving environmental sustainability will be a big challenge. The challenges will have to focus on population, CO_2 emissions, annual GDP growth, energy consumptions, climate condition, emission intensity, and effective technology for CO_2 reductions.

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