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Urban Population Growth and the Environment in China: An Investigation

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Abstract

The controversy surrounding population growth-environmental nexus is waning as recent evidence from streams of literature confirmed such linkages. One such study is the effect of rapidly growing urban-population-growth on the environment in China, and this paper investigates the link between urban-population-growth and carbon dioxide emissions from fuel combustion from residential buildings, commercial and public services. Based on the data collected, a ʌ-shaped similar to N-shaped Environmental Kuznets Curve has been found: linear, square and cubic relationships have been found to exist between urban-population-growth and the environment. The findings further indicate that with or without the controlled variables, the coefficients of urban-population-growth are statistically significant, and causal relationship exists. This paper contributes to the growing literature on the debate between population-growth and the environment. The urban-population-growth and the environment appeals may be an appropriate strategy to get the attention of policymakers to act.

JEL classification numbers: C23, C52
Keywords: Urban population growth, environmental stress, pollution emissions, Environmental-Kuznets-Curve.

1 Introduction

Today's rapid-paced China is becoming increasingly urbanized characterized by rapid industrialization, population density, and lax environmental oversights are responsible for environmental issues and large scale pollution. Despite population control of birth rates (one-child per family), China still remains the most populous country in the world. According to Geping, Jinchang, Baozhong, Ran & Boardman (1994) and Kai &Lihong (2012), rapid increases in population in the 1950s and 1960s are responsible for the major cause of population problems in 1970s. High population pressures, poor population

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characteristics
and unequal distribution affect the country's development. The inevitable consequences of these pressures lead to social, economic and environmental problems.

The fourth national population census estimated that as at July 1, 1990, the 1.16 billion marks was attained. This represents 2.1 times the figure in 1949, and accounted for 21.9% of the total global population. The sixth national population census estimates the total human numbers in China (including Hong Kong special administrative region- 7,097,600 persons, Macau special administrative region- 552,300 persons and Taiwan- 23,162,123 persons) to be 1,370,536,875 persons. This accounted for 5.84% growth rate between 2000 and 2010, an average growth rate of 0.57%. The total human number also shows an increase of 73,899,804 persons from previous census conducted in 2000 (National Bureau of Statistics of China 2011). Rapid population growth in urban areas has intensified the demand for the available limited resources: demand for timber and firewood, agricultural land for cultivation, water, food and housing have all increase pressures on land (Ehrlich and Holdren 1970).

The purpose of this study is to contribute to the theoretical understanding of the population growth-environmental nexus. China is home to almost 1/4th of the global population and is urbanizing at a pace faster than any other country, resulting in "an unprecedented growth in urban residents and increased number of densely populated mega-cities." The consequence of this is that the region is experiencing greater environmental challenges such as air pollution, congestion, CO_2 emission, water scarcity, basic sanitation problem, and growing vulnerability to natural disasters. However, the features of rising urbanization present a lot of opportunities which culminate in some economic gains. For example, it increases the number of middle-class and property owners, "the development of the service sector, declining fertility and increased educational attainment, and more importantly, innovations in green technology" (Asian Development Bank 2012).

Past research on population-environment nexus has concentrated on two broad issues: first, population growth and the environmental impact linkages. Considering the issue of China in particular, population growth rate is less than 1% and not a major concern when compared with developing countries such as sub-Saharan African countries and other low-income countries. Consideration of direct urban-population-growth rates on the environment remains a poorly articulated but potentially vital facet of the Chinese regional and global change; second, taking into account the issue of population-environment nexus model in particular, the literature is almost silent on the details of theoretical underpinning population-environment connection stages and their interface with Co_2 emissions from residential buildings and commercial and public services (pollution emissions). Consequently, we have an incomplete picture of the way urban population growth andenvironment are linked (Bartlett 1994 &Kotze 2007).

Against this background, the goal of this study is to answer the research question: how might we link the association between the urban-population-growth and the environment? More specifically, the study has two objectives: a) to test whether there is an Environmental Kuznets curve for urban-population-growth and Co_2 impact and b) to explore the causal association between urban population growth and carbon dioxide (Co_2) emissions from residential buildings and commercial and public services.

This research attempts to identify the key stages of how urban population growth affects the environment and tied urban population to pollution emissions. Essentially, this study responds to the call for a new thinking about the relationship between urban population growth and the environment and draws inspiration from Kozte (2007), Ehrlich &Holdren (1970), Ehrlich & Holdren (1971), Holdren & Ehrlich (1974) and Bartlett (1994& 1998) who have stressed the need for a better understanding of both relationships.

The findings of this paper are expected to generate a better understanding of the relationship between urban population growth and the environment, and the magnitude effects of urban-population-growth on the environment.

The paper is organized in four sections. Section II reviews the literature review, section III discussed methodology and data analysis techniques, section IV discussed the research findings and the paper concludes in section V.

2 Literature Review

Dietz & Rosa (1994) argue that the effect of population growth on the environmental resources and human welfare is as old as civilization, in fact as old as history itself. Heroditus, cited in Dietz & Rosa (1994) ‘‘writing in the 5th century before Christ, noted how the population of the Lydians had outpaced production leading to a prolonged famine that lasted eighteen years (The History Book 1:22-23).’’ Dietz & Rosa (1994) find that a causal link between population and resources grow and developed into a more concrete form in the eleventh century. In the late 18th and early 19th century, Malthus laid the foundation of social scientific origin when he claimed that population was growing at a geometrical progression whereas the food production was growing at an arithmetic progression. This ingenuity led to human numbers- environment interactions and ‘‘species dependency on finite resources was soon recognized”. Scholarly studies of population and indeed observation of the population as a “potential threat to nature and to human well-being” dated back in the “documented history of human thought” Engleman (2012). Cohen (1995) cited in Engleman (2012) argues that a recorded history has existed relating to human thoughts from clay tablets since 1600 BCE, documented divine displeasure with multiplying humans sound indicated that “the land was bellowing like a bull”. It is also noted that Plato and Aristotle argued against large population for ecological and governance reasons. Plato argued that deforestation and soil degrading will affect ancient Greece while Aristotle argued in favor of small population size since it is easier to govern than a large population size (Engleman, 2012). According to Engleman (2012), the Indian sage and Chinese scholars around 300 BCE “decried” the social and environmental effects of large and growing populations. Hutchinson (1967) notes that “the earth is inexhaustible and increases its fertility in proportion to the number of inhabitants who cultivate it.”

Ehrlich &Holdren (1970) state that the factors that account for environmental disruption as a result of population size and growth are: diminishing returns is operative in increasing food production to meet the teeming growing human population; overproduction on land; richest fisheries stocks are depleted. These depleted stocks are not recoverable. Population size affects per capita impact in terms of links with every other person- roads, telephone lines, computer network, cars, etc. The number of links increases more rapidly than the number of people, so is per capita consumption associated with the links. At a certain level of pollution, polluted trees will survive in smog (Ehrlich &Holdren, 1971), but when a unit of increase in population produces a small increase in smog, “living trees become dead trees”. Synergism is also capable of causing near-discontinuities; and the cost of maintaining environmental quality escalates disproportionately as population size rises. Ehrlich & Holdren (1971) note that a growing avalanche of scholarly literatures focused on US population growth and the impact on the environment: "perhaps the most serious of these is the notion that the size and growth rate of the US population are only minor contributors to this country's adverse impact on local and global environments".Ehrlich & Holdren (1971) are well known authorities on human population size and growth vis-à-vis the environment. Ehrlich and Holdren developed five theories and affirmed their truth. These theorems cemented the framework for analysis. These theories are:

a). Population growth affects the environment by causing a "disproportionate negative impact on the environment", pp: 1213.

b). The need for joint consideration of the population size and growth, resource utilization and depletion and environmental deterioration on a global context.

(c). Using population density as an indicator of population size and growth is not a good measure of population pressure. Thus, an attempt to distribute population would be a false-solution to the constant growing population problem.

(d). The environment must be properly defined and construed to include such things as "the physical environment of urban ghettos, the human behavioral environment, and the epidemiological environment".

e). Ehrlich & Holdren (1971) suggest practical and concrete solutions rather than theoretical solutions. They claimed that "theoretical solutions to our problems are often not operational and are not the real solutions.

Nagdeve (2007) investigates the changes and trends of population growth in India over the last 50 years, and conducted the analysis of the impact of population growth on the environment. The study notes that population growth is imposing a burden on the resource base. This study notes that "environmental effects like ground water and surface water contamination; air pollution and global warming are of growing concern owing to increasing consumption levels." The conclusion is that overall development should take into account control of population growth and environmental degradation.He argues further that the pace of population growth and economic development both have an influence on the environment. The environment is degraded through "uncontrolled urbanization and industrialization, expansion and intensification of agriculture, and the destruction of natural habitat."

Shah (2002) and Holdren & Ehrlich (1974) papers point to the ecological limit that can sustain man, and this limit is set by such factors as human population growth (HPG), the way we consume, live and manage the available resources. Shah (2002) and Ehrlich & Holdren (1971) provide valuable insight into the poor regions of the world as there are "high population and environmental degradation as the problem." They notes that as human population increases "food is becoming scarce" and many people cannot afford it. The study argues that the main cause of scarcity is the "international trade, economic policies and the control of land that have led to immense poverty and hunger, and therefore less access to food, not food scarcity due to overpopulation."

Engleman (2012) argues that the "trends in ratios of population to specific natural resources often have direct relevance to environmental sustainability." An important example is that as populations grow each individual struggle for freshwater and cropland as these resources becomes scarce. The indicators of population growth to natural resource nexus are important for determining scarcity, conflict and tension while population distribution also plays an important "connections to the discussion of environmental sustainability." In 2007, the United Nations Population Division argued that half of the world human population lived in urban areas. Engleman (2012), Nagdeve (2007), Dietz & Rosa (1994), and Bartlett (1994) studies confirm that climate change continues to increase the "relevance of population as a sustainability indicator". The study further argued that the Intergovernmental Panel on Climate Change (IPCC) also noted a connection between population growth as part of the "four drivers of increasing greenhouse gas emissions", while the others are economic growth, changes in energy intensity of economies, and changes in the carbon intensity of energy. This relationship is referred to as the Kaya identity. According to Shah (2002), Ehrlich & Holdren (1971) and Engleman (2012), recent studies reveal that climatologists are making projections of "future emissions" on the basis of "different projections of population growth," and population growth has become an important independent variable in future emissions. Ehrlich & Holdren (1971) andEngleman (2012) reports that population growth, density or pressure are the major factors considered by governments of LDCs which hinder their capacity to "adapts to the impacts of climate change". The study also argues that higher population growth rates are positively correlated to low per capital income. This leads to the argument that consumption is more relevant than population "in the matter of sustainability". This is based on the fact that people in the developed regions of the world have "greater environmental impacts" than people in LDCs, because consumption of resources is higher in the former than in the later. Engleman (2012) cited the examples of China, India, and the United States which indicate that both population and consumption growth "can be out of sync and yet still combine powerfully over time to influence the environment". The study reiterates United States of America as an example of a wealthy country with population growth throughout most of the nineteenth century at annual rates similar to those featuring the "populations in many developing countries today". Yet the amount of fossil fuels consumed was small when compared with the twentieth century population growth rates when fossil fuels increased. China also had a similar rapid population growth and this resulted in rapid consumption growth a century later (Engleman 2012). It is argued that the "size and growth of the world's human population" is one of the critical factors in sustainability, which support stable civilization. Despite this evidence, complexities still surround the population-environment nexus, though Engleman (2012) states that "as human numbers further increases, the potential for irreversible (environmental) changes of far-reaching magnitude also increases. In our judgment, humanity's ability to deal successfully with its social economic and environmental problems will require the achievement of zero population growth within the lifetime of our children". The study also identified human population growth (HPG) as one of the critically important indirect "driver of environmental change," with economic growth and technological evolution.

Hutchinson (1967) argues that factors such as consumption, government policies or uses of technology, dwarf the consequences of human numbers. It is further argued that there exists no strong correlation that is neat and direct which connect to a specific environmental problem with absolute population numbers. Another similar school of thoughts also notes that population is not a "sustainability indicator at all". In contrast, a different sets of literature argued that population numbers and growth rates are the most critical and important elements of sustainability indicators of all other factors, because population is an important scale factor which underline environmental problems (Engleman 2012).

2.1 Definition

Let

$$EVNT = P.F \tag{1a}$$

Where P = the population, F = functions which measures the per capita impact and EVNT = the total impact of the environment

3 Main Results

In this paper, we first estimated equation (2), since the model is constructed to include only UPOPG, $UPOPG_t^2$ and $UPOPG_t^3$, and this enables us to determine at which level of urban population growth is environmental pressure more serious (excluding other control variables). It also indicates whether the environmental Kuznets curve (EKC) does exist between urban population growth and the environmental quality. Then, estimation of equation (3) considered whether the impact of urban population growth (UPOPG) on the environmental quality will be changed with changes in GDP growth, NTD, FDItibop and TECH. Equation (4) include the control variables in model (equation) 2 to determine whether the EKC exists with the inclusion of control variables.

The three equations are estimated by Newey-West andPrais-Winsten estimators, the first estimator is used to estimate the covariance matrix of the parameters of a regression model where the standard assumptions of OLS regression analysis do not apply. It is also used to surmount the problems of autocorrelation, or correlation, and homoskedasticity in the error terms in the models. The effects of correlation in the error terms can be corrected by Newey-West estimator, particularly in regressions applied to time series data (Newey& West 1998). Whereas Prais-Winsten is a process that is used to take care of serial correlation type AR (1) in a linear model, it is a modification of the Cochrane - Orcutt and leads to more efficient results. According to Hardin (1996), Prais-Winstenregression addresses the problem of autocorrelation, though we often get very large coefficients on either the variables or the constant term. On the basis of this, we surprised the constant term though these do not arise when we use OLS. In this approach, the estimation of equations (2), (3) and (2) is carried out by Newey-West and Prais-Winsten estimators. The results are displayed in Table 1, Table 2 and Table 3.

The estimated output in Table 1 which comes from equation (2) shows that there is the presence of EKC in China. The coefficients of UPOPG are correctly signed and statistically significant. Whereas coefficients of $UPOPG^2$ and $UPOPG^3$ are incorrectly signed, but are statistically significant. This show that a rapidly increasing urban population growth leads to increase in pollution emissions (percentage of total fuel combustion from residential buildings, commercial and public services) until the urban population growth reaches a certain size, and decreases thereafter, a typical **'ʌ-shaped'** environment Kuznet curve (EKC) is formed. It takes the form of N-shaped environmental Kuznet curve, and indicates that UPOPG increases environmental impacts during the first phase and second phase, as UPOPG grows the impact risesand causes environmental problems. Specifically, urban population growth in China is a determinant of Co_2 emissions from residential buildings, commercial and public services. The coefficient of the UPOPG (our starting point) is worth 9.02 x 10,000 = 90200 metric tons of pollution emission. In quantitative magnitude terms: the $UPOPG^2$ shows that the pollution emission rises by 9.02 + 2 (4.48) (1) = 9.02 + 8.96 = 17.98 x 10,000= 179800 metric tons pollution emission, the coefficient of the cubic $UPOPG^3$ reduces environmental pollution emissions by 9.02 + 2 (4.48) (1)-3 (1.88) (1) = 17.98-5.64=12.34 x 10,000 = 123400 metric tons. The coefficient of the cubic term of $UPOPG^3$ is negative and statistically significant. This shows that high rateof urban population growth is eventually associated with slowing environmental pollution emissions. The estimated results behavior is like an N-shaped EKC, after the initial up in pollution emission at UPOPG, and $UPOPG^2$ and decreases steadily at $UPOPG^3$. The ʌ-shape of Co_2 pollution emissions increases again. Gao, et al. (2011) argue that "these generate diminishing returns in terms of pollution- reducing technology change".

In equation (3), when variables such as UPOG, GDPgrowth, NTD, FDI and TECH which determine environmental quality are included in the model without the second and third phase of UPOPG (i.e. excluding $UPOPG^2$ and $UPOPG^3$), we find that all the coefficients of the variables are correctly signed except FDI, and are all statistically significant at different significant levels expect GDP growth. In fact, UPOPG is statistically significant and strong at 1% level of significance.

In equation (4), we included control variables such as per capita GDP growth rate (GDPgrowth), foreign direct investment (FDI), net trade(NTD), and technology (TECH) in the model, which are determinants of environmental quality. We also find that there is a 'ʌ-shaped environmental Kuznets curve' in the equation (4) which support the equation (2) that UPOPG impact on environmental quality. Here, the coefficient of the UPOPG (our starting point) is worth 18.37 x 10,000 = 183700 metric tons of pollution emission. The $UPOPG^2$ shows that the pollution emission rises by 18.37 + 2 (2.90) (1) = 18.37 + 5.8 = 24.17 x 10,000= 241700 metric tons pollution emission. The coefficient of the cubic $UPOPG^3$ reduces environmental pollution emissions by 18.37 + 2 (2.90) (1)+3 (-4.72) (1) = 18.37 + 5.8 -14.16=24.17-14.16= 10.01 x 10,000 = 100100 metric tons pollution emission. The findings indicate that the coefficient of UPOPG is positive and statistically significant at 1% level of significance. The coefficient $UPOPG^2$ is incorrectly signed and not statistically significant. The coefficient $UPOPG^3$ is not correctly signed but statistically significant at 5% level of significance.

The coefficient of the control variable-GDP per capita growth is positive as we expected and statistically significant at 10% level of significance. This shows that an increase in the growth rate of per capita GDP leads to a rise in pollution emission by 0.056 x 10,000 = 560 metric tons. The net trade is also correctly signed and statistically significant at 10% level of significance. A unit increase in net trade improves environmental quality by -4.10 (10,000) = 410000 metric tons. The coefficient of FDI is negative and not statistically significant. It indicates that there is no evident proof of "pollution haven" hypothesis. The variable TECH has a negative coefficient and it is not statistically significant. This shows that as the state of technology increases, it has no impact on environmental quality. The net trade (NTD) confirmed the study of Gao, et al. (2011) that there is the presence of a relationship between NTD and pollution emissions, that free trade may act to reduce pollution emissions as increase competitive pressures encourage countries to become more efficient with their resources.

3.1 Methodology

3.2 Data Sources and Variables

The data used in this study are yearly time series data set of China from 1960-2012, which were collected from World Bank data bank statistics 2012.
The Table 1. Below capture the various variables used in this study.

Variable	Definition/indicator	Unit
Environmental impact (ENVT)	Emission of Co_2,	10,000 metric tons
GDP per capita	Per capita GDP	constant, US Dollar
NTD	Openness: total Exports-exports	US $10,000
FDI	Foreign direct investment	US $10,000
UPOPG	Urban Population growth	Growth rate
TECH	Growth rate of technology	Growth rates

3.3 Models

The research adapted, but modified the model of Ehrlich and Holdren (1971) in equation 1, and Gao, et al.(2011) in equations 2, 3 and 4. According to Ehrlich and Holdren 1971, the total negative impact of the destabilization of the ecological systems resulting from the practice of agriculture, participation in the utilization of renewable and non-renewable resources in a society on the environment" can be expressed symbolically as

$$EVNT = P.F \quad (1a)$$

Where P = the population, F = functions which measures the per capita impact and EVNT = the total impact of the environment
Gao, et al. (2011) modeled Environmental Kuznets curve for So_2 emissions in China:

$$So_2 = b_0 + b_1(PGDP) + b_2[(PGDP)^2{}_{it} + b_3[(PGDP)^3]_{it} + f_i + V_{it} \quad (1b)$$

Abdulrasaki Saka
Where: Subscript i = ith province, t = tth year, f_i = unobservable effect (a set of province-level characteristics), v_{it}= province specific error term, So_2= emissions of sulphur dioxide,
PGDP = per capita GDP (income level) and $(PGDP)^2$ and $(PGDP)^3$ are quadratic and cubic forms of PGDP.

Our modified model becomes:

$$Co_{2t}=\alpha_0 + \alpha_1 UPOPG_t + \alpha_2 UPOPG_t{}^2 + \alpha_3 UPOPG_t{}^3 + U_t \quad (2)$$

$$Co_{2t} = \alpha_0+\alpha_1 UPOPG_t+\alpha_4 GDPC_t+\alpha_5 NTD_t+\alpha_6 FDI_t+\alpha_7 TECH_t+U_t \quad (3)$$

$$Co_{2t}=\alpha_0+\alpha_1 UPOPG_t+\alpha_2 UPOPG_t{}^2+\alpha_3 UPOPG_t{}^3+\alpha_4 GDPC_t+\alpha_5 NTD_t+\alpha_6 FDI_t+\alpha_7 TECH_t+U_t \quad (4)$$

Where t represent year, U_t is the error term, the variable Co_{2t} is the emissions from residential buildings, commercial and public services (% of total fuel combustion) is the proxy variable for environmental quality and UPOPG is the urban population growth rates; $UPOPG_t^2$ and $UPOPG_t^3$ are the quadratic and cubic forms of UPOPG respectively. U_t is the error term. The GDPC is the gross domestic product per capita which captured affluence, NTD is the net trade which is the same as openness, the variable FDI is the foreign direct investment (as urban population increases rapidly, it indicates an increase in market size as well as cheap labor cost, and foreign investors are encouraged to invest more, all other things else remaining the same). As this happens, it can further lead to urban poverty, slums, and crimes as more and more people are attracted by the job opportunities and other benefits of urban cities. All these effects put pressure on the environment. The FDI simply test the "pollution haven" hypothesis, which is also a determinant of environmental degradation.

A quadratic function having a negative quadratic term (if $\alpha_2 < 0$) and a vertex at a level of population growth within the data range depicts the environmental Kuznets curve (though the linkages between environmental damage and GDP are usually associated with environmental Kuznets, but it is also possible to associate environmental impact and population growth with environmental Kuznets - see Stern, Common &Barbier (1996); Lubchenco (1998); Curran, Kumar, Lutz & Williams (2002) and Gaudie (2006)). This implies that environmental impact increases at the initial stage of population growth but at a decreasing rate, "up to a point when the first derivative changes sign" and a de-nexus of population growth and environmental pressure takes place. A cubic term of urban population growth is included in the model to test the proposition that environmental pressure tends to increase once again as the urban population increases more rapidly than expected (Gao, et al. 2011). The a priori expectation are: the coefficient of $UPOPG_t$ is expected to have a positive sign, the coefficient of $UPOPG_t^2$ will capture a negative sign, we anticipate the coefficient of $UPOPG_t^3$ to have a positive sign, an upward bend of the Kuznets curve at the very high-UPOPG will be captured by α_3. We anticipate the coefficient of $GDPC_t$ to have positive signs. The coefficients of NTDt, and TECHt may have either a negative or positive relationship with pollution emission ("efficient resource use and increased competition" as international trade increases see Gao, et al. 2011). The TECH and FDI are important determinants of Co_2 emission which test the technology use and "pollution havens" in relationship with the environmental quality.

4 Labels of Figures and Tables

Table 1: The estimates of environmental quality (test of environmental Kuznets Curve)
Regression with Newey-West standard errors excluding control variables
Dependent variable: Co_2rcppsptfc (Co_2) emissions

Variables	Coefficients	Newey-West Std. errors	t-statistics	P-values
UPOPG	9.02	1.07	8.42***	0.000
$UPOPG_t^2$	4.48	1.23	3.62**	0.001
$UPOPG_t^3$	-1.88	0.33	-5.70***	0.000
F- Value	988.68			
Prob> F	0.000			

*, ** and *** all represent statistically significant at 10%, 5% and 1% respectively.

Table 2: The estimates of environmental quality (test of causality between UPOPG and Co_2 emissions)
Regression with Newey-West standard errors and other control variables
Dependent variable: Co_2rcppsptfc (Co_2) emissions

Variables	Coefficients	Newey-West Std. errors	t-statistics	P-values
UPOPG	11.09	0.56	19.53***	0.000
GDP growth	0.88	1.59	0.91	0.374
NTD	1.44	0.04	1.93*	0.065
FDItibop	-4.93	2.13	-2.31**	0.029
TECH	0.06	0.01	3.63***	0.001
F- Value	3252.36			
Prob> F	0.000			

*, ** and *** all represent statistically significant at 10%, 5% and 1% respectively.

Table 3: The estimates of environmental quality (test of environmental Kuznets Curve)
Prais-Winsten regression with other control variables
Dependent variable: L9. Co_2rcppsptfc (Co_2) emissions

Variables	Coefficients	Newey-West Std. errors	t-statistics	P-values
UPOPG	18.37	2.49	7.37***	0.000
$UPOPG_t^2$	2.90	3.95	0.73	0.471
$UPOPG_t^3$	-4.72	1.57	-2.99**	0.007
GDP growth	0.056	0.042	1.34*	0.195
NTD	-4.10	2.32	-1.77*	0.091
FDItibop	-2.76	3.85	- 0.72	0.481
TECH	-0.01	0.02	-0.73	0.474

F- Value	2947.87	DW stat. (original)	1.63
Prob> F	0.000	DW stat. (transformed)	2.16
Rho	0.10	R^2	0.99
Root MSE	0.52		

*, ** and *** all represent statistically significant at 10%, 5% and 1% respectively.

5 Conclusion

In both equations (2) and (4), three phases are identified. The first phase- UPOPG is high and causes environmental stress to increase. The second phase is when $UPOPG^2$ are higher and environmental stress levels appear uncontrolled and observation of increases is observed. In phase 3, $UPOPG^3$ appears at a high population growth rate when emissions decrease rapidly. Both UPOPG and $UPOPG^2$ are consistent with Malthusian tradition which supports the view that a rapidly growing population causes natural resource scarcity, whereas UPOPG3 has a theoretical support with Boserupian tradition which argued that population growth in size or density causes agricultural intensification which in turn leads to technological beak-through. This shows that the impact of urban population growth rate on environmental stress is more significant in all the phases in model (2) while urban population growth determines pollution emission in model (4) in both phase one and phase three, because phase two is not statistically significant.

The linear model in equation (3) also indicates that UPOPG is correctly signed and strongly significant supporting the Environmental Kuznets Curve that urban population growth causes environmental stress in both models (2) and (4). The coefficients of GDP growth, NTD and TECH all meet the a priori expectations except FDI, and all statistically significant except GDPgrowth.

The study test and find that there exists an Environmental Kuznets Curve between urban population growth and pollution emissions in China. We find that urban population growth in China contributes to carbon dioxide (Co_2) emissions from fuel combustion from residential buildings, commercial and public services (pollution emissions increases from 183,700 to 241,700 and declined by 100,100) metric tons in phases one, two and three in model (2); in model (4), it (increases from 90200 to 179,800 and reduces by 123,400) metric tons, and the linear model (3), the UPOPG causes pollution emission by 110,900 metric tons, on the average holding all other variables constant. The studies of (Ehrlich & Ehrlich 1970; Holdren& Ehrlich 1974; Bartlett 1994 and Gao, et al. 2011) also find similar results. This means that we can partition pollution emissions experienced in urban areas in China into two phases. In the first and second phases environmental damage is shown to increase at an increasing rate and this continues into phase two. In phase three the environmental stress is shown to decrease in both models (2) and (4). This might be as a result of the capacity constraint of the UPOPG to emit pollution at a decreasing scale effect. The paper of Gao, Gao, et al. (2011) confirmed the existence of EKC in China as it linked economic growth with environmental quality. This paper also finds the existence of causality between UPOPG and pollution emissions in urban areas in china in model (3) because UPOPG caused pollution emissions by increase in 110,900 metric tons, on the average when all other variables are equal to zero.

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