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The disappearing Environmental Kuznets Curve: A study of water quality in the Lower Mekong Basin (LMB)

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ABSTRACT

The literature is flush with articles focused on estimating the Environmental Kuznets Curve (EKC) for various pollutants and various locations. Most studies have utilized air pollution variables; far fewer have utilized water quality variables, all with mixed results. We suspect that mixed evidence of the EKC stems from model and error specification. We analyze annual data for four water quality indicators, three of them previously unstudied – total phosphorus (TOTP), dissolved oxygen (DO), ammonium (NH_4) and nitrites (NO_2) – from the Lower Mekong Basin region to determine whether an Environmental Kuznets Curve (EKC) is evident for a transboundary river in a developing country and whether that curve is dependent on model specification and/or pollutant. We build upon previous studies by correcting for the problems of heteroskedasticity, serial correlation and cross-sectional dependence. Unlike multi-country EKC studies, we mitigate for potential distortion from pooling data across geographically heterogeneous locations by analyzing data drawn from proximate locations within a specific international river basin in Southeast Asia. We also attempt to identify vital socioeconomic determinants of water pollution by including a broad list of explanatory variables alongside the income term. Finally, we attempt to shed light on the pollution–income relationship as it pertains to trans-boundary water pollution by examining data from an international river system.

We do not find consistent evidence of an EKC for any of the 4 pollutant indicators in this study, but find the results are entirely dependent on model and error specification as well as pollutant.

1. Introduction

The majority of empirical Environmental Kuznets Curve (EKC) literature focuses on air pollution and income. In a meta-analysis of 255 EKC studies published between 1995 and 2010, Jordan (2010) finds that only 35 studies use water quality indicators as the dependent variable in comparison to 214 studies that use air, climate and energy indicators. Of the few studies that do focus on water pollution, only 10 were performed at the lake and watershed level. Trans-boundary water pollution also remains an under-explored realm of EKC research. This gap in the literature is puzzling as many of the most productive water systems in the world cross multiple political borders. Almost half of the world's continental surface area is covered by river and lake basins located within the geographical borders of two or more countries and approximately 60% of the world's freshwater flow can be traced to them. Approximately 40% of the world's population resides within these trans-boundary rivers and lake basins (UN-Water, 2008). We aim to contribute to the empirical literature by investigating whether an EKC relationship can be found in the Lower Mekong Basin (LMB), a transboundary river basin shared by four Asian countries.

1.1. Study area

The study of the relationship between pollution and income in the LMB is interesting for several reasons. At over 4800 km the Mekong River is one of the longest rivers in the world. From its source in the Tibetan Plateau of Qinghai Province, Western China the river runs through the Yunnan province of China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam before reaching the South China Sea at the Mekong Delta. Around 60 million people currently reside in the LMB. The LMB is also currently home to some of the fastest growing economies in Asia. During the period 2004–2008, Cambodia, Lao DPR, Thailand and Vietnam reported average GDP growth in the range of 7.3–13% (MRC, 2010).

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The Mekong River region is extremely rich in biodiversity. The area contains 16 World Wildlife Federation Global 200 ecoregions – which are defined as areas with exceptional levels of biodiversity and of singular biological character (MRC, 2010). The livelihoods of most LMB residents are tied to the river and its water resources. Water from the river is used for the irrigation of crops. The agricultural sector within the LMB contributes up to 85% of the total workforce in some areas (MRC, 2003). The river also represents a significant source of food security for LMB residents. In Cambodia – the poorest of the 4 LMB countries – over 75% of protein intake among rural residents is derived from fish and aquatic sources (MRC, 2003). The fisheries industry generates a substantial amount of income for the region's economies. The Mekong and its extensive network of tributaries and distributaries also facilitate the transportation of goods and people. The extreme reliance by residents of the LMB upon water resources for subsistence and also the functioning of day-to-day activities underlines the degree to which the local inhabitants are vulnerable to changes in river conditions due to environmental degradation.

1.2. Previous work

The theory of the existence of an Environmental Kuznets Curve posits that there is an inverted U-shape relationship between income (GDP) and pollution. The theory suggests that as countries grow in wealth, environmental degradation initially worsens as measured by environmental health indicators, but as wealth rises even further pollution levels eventually start to fall, suggesting a transition to a cleaner environment. Empirical studies to date have been conducted using different environmental indicators, different geographical locations, different time periods and different econometric techniques.[1] The published literature highlights a variety of different relationship-types along with a wide array of turning point estimates. This lack of consensus has plagued even the earliest attempted EKC studies (Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992; Selden and Song, 1994; Shafik, 1994; Grossman and Krueger, 1995).

Many empirical EKC studies have attempted to detect global EKC relationships by analyzing large multi-country datasets. However, as Carson (2010) and Stern (2004) point out, the relationships and coefficients estimated in such regression studies may vary depending on the study sample – the types of countries included or excluded. As such, this raises questions as to the representativeness of the study sample and consequently the generalizability of study results from one sample to another. By limiting the scope of our study to a specific region, we reduce the likelihood of distortions caused by unobserved heterogeneity.

In a survey of the literature, Dinda (2004) points out that the type of environmental indicator studied can affect the likelihood of discovering an EKC. The majority of studies conducted on local air quality indicators (Grossman and Krueger, 1991; Selden and Song, 1994; List and Gallet, 1999; Stern and Common, 2001; etc.) such as sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NO_x) and suspended particulate matters (SPM) exhibit the inverted-U shape of the EKC while studies of other pollutants such as industrial or municipal wastewater pollution (Shafik, 1994; Cole et al., 1997; De Groot et al., 2004) and carbon dioxide (Moomaw and Unruh, 1997; Agras and Chapman, 1999; Ansuategi and Perrings, 2000; Stern and Common, 2001; etc.) do not display the inverted U-shape pollution–income relationship. Arrow et al. (1995) first observe the different pollution–income relationships likely to be displayed by stock and flow pollutants but Lieb (2004) expands upon this work by providing theoretical explanation of these differences. The abatement efforts of myopic governments will always be focused on flow pollutants as the abatement of stock pollutants does not result in the immediate reduction of stock pollutant levels or in clear and immediate benefits for the present generation. As such, the EKC relationship is more likely to exist for flow pollutants as opposed to stock pollutants. Pollutants such as SO_2, CO, NO_x, SPM and many water pollutants are considered flow pollutants as they do not persist in the environment for an extended period of time.

Recently we have seen an increase in EKC research focused on developing countries and in particular those located within Asia (Barua and Hubacek, 2009; Hung and Shaw, 2004; Narayan and Narayan, 2010; Shaw et al., 2010; Taguchi, 2012: Vincent, 1997) and in particular in China (see, for example, Brajer et al., 2008; De Groot et al., 2004; Jalil and Mahmud, 2009; Shaw et al., 2010; Shen, 2006; Song et al., 2008). However, like the rest of the EKC literature, these studies have almost exclusively focused on local air pollutants and employed econometric techniques that don't address the challenges outlined in this paper. Only a few studies have focused on the LMB region (Guo and Yang, 2003; Dasgupta et al., 2005; Guo and Zhao, 2011), leaving an even greater gap in the research community's understanding of the pollution-income relationship – as well as the impact on socio-economic conditions, many of which are within the control of government policy upon this relationship – within an incredibly bio-diverse and economically productive area. The work undertaken in this paper most closely on surface resembles the work of Guo and Yang (2003) and Guo and Zhao (2011).

1.3. Transboundary rivers

Other theoretical research lends support to the notion that EKC relationships differ based upon the different spatial and temporal environmental costs associated with different pollutants. Assuming rational behavior on the part of polluting agents (for the most part, assumed to be individual countries), the de-linking between income and pollution on the downward portion of the EKC is less likely to take place when (i) the most pernicious impacts of pollution are experienced by those residing in territories and administrative units outside of that in which the pollution takes place or (ii) the benefits of pollution control are more likely to accrue to individuals and communities in territories outside of where the controls are imposed (Ansuategi and Perrings, 2000). These two conditions generally hold for pollution that occur across borders i.e. global pollutants such as CO_2 emissions. Sigman (2002) finds that for international rivers where international spillovers may occur, pollutions levels at measurement stations upstream of international borders report higher levels of pollution compared to other stations. Consequently, in cases where trans-boundary pollution spillover is likely to occur, theory predicts that the EKC relationship is less likely to be observed.

Water quality indicators are generally measurements of microbiology concentration (fecal bacteria, total coliforms and Chlorophyll A), concentrations of heavy metals and toxic chemicals (arsenic, mercury, lead, DDT, phenols, etc.) and the state of the water oxygen regime (biochemical oxygen demand, chemical oxygen demand, and dissolved oxygen). Much like their air quality counterparts, studies involving measures of water quality also yield a mix of results. As Table A1 (see on-line supplementary materials) indicates, several previous studies (Grossman and Krueger, 1995; Cole, 2004; Shen, 2006) find evidence of inverted U-shape relationships for a variety of water based indicators while a number of other studies yield results that suggest other relationship types. De Groot et al. (2004) find a monotonically declining relationship

[1] The authors can provide appendix tables that summarize a large selection of EKC studies that are differentiated along these dimensions on request.