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Fiscal spending and air pollution in Chinese cities: Identifying composition and technique effects

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ABSTRACT

Fiscal spending has both direct and indirect impact on the environment. Using city-level data in China, this paper investigates if education spending affects air pollution through human capital accumulation, known as the composition effect, and if R & D spending affects air pollution through clean-technology adoption, known as the technique effect. Contrasting theoretical predictions and previous empirical evidence, we find both effects of interest to be trivial in urban China. Composition effect appears to be slightly stronger relative to technique effect, while subsample analyses show some regional heterogeneities. The results remain robust when we switch between pollution measurements, examine only the regional central cities, instrument endogenous covariates, and adopt the spatial settings. We further discuss potential channel-blocking mechanisms that lead to weak estimates.

1. Introduction

Air pollution plagues modern Chinese cities. While China's fast economic growth has long been relying on GDP-oriented industrialization and urbanization, the deterioration of ecological and environmental quality has become increasingly noticeable in urban areas (Zheng & Kahn, 2017). Factory and vehicular combustion of fossil fuels generate Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_X) and suspended particulate matter (SPM) that lead to recurrences of toxic smoggy weather and contamination of urban aquatic systems. In 2014, the Chinese central government released the "National New-Type Urbanization Plan (2014–2020)" in which the abatement of urban air pollution is officially scheduled to be achieved in the construction of "pro-environmental cities".

The restoration of environmentally amenable cities requires an in-depth understanding of the economic determinants of urban air pollution.[1] Among a broad set of candidate factors, this study examines the effect of public fiscal spending on the level of local air pollutants, motivated by the fact that excessive air pollution is essentially the result of market failures that unavoidably necessitate government intervention. Existing theory suggests that the level and composition of government expenditure may affect environmental pollution through several channels (Huang, Chen, Huang, & Yang, 2016; Lopez, Galinato, & Islam, 2011; Lopez & Islam, 2008). First, economic growth generated by an increased fiscal spending creates more pollution (a scale effect). Second, reallocation of

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[1] Studies on economy-pollution interactions have grown in recent decades since the seminal World Bank Development Report (1992) and Grossman and Krueger (1993). Shafik and Bandyopadhyay (1992), Seldon and Song (1994), and Grossman and Krueger (1995) are some of the earliest studies that show the inverted U-shaped relationship between environmental degradation and income, known as the Environmental Kuznets Curve (EKC). Kaufmann, Davidsdottir, Garnham, and Pauly (1998) report a quadratic relationship between the spatial intensity of economic activity and SO_2 concentration. Technological improvements and high-tech firms are found to be helpful in relieving air pollution in developed countries (Suri & Chapman, 1998), while urbanization increases both CO_2 emissions and energy footprint (York et al., 2003).

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government spending in favor of education tends to raise the share of cleaner human capital-intensive activities relative to the share of dirtier physical capital-intensive activities (a composition effect). Third, more fiscal spending on R & D can result in a higher adoption rate of cleaner technology by firms that reduces the pollution-output ratio (a technique effect). Finally, private income raised by public-good expenditures leads to higher demand for a cleaner environment and more stringent regulations (an income effect). In this study we focus on the identification of composition effect and technique effect, which receive much less discussion in the literature relative to the other two effects.

Existing empirical studies on the effect of government size (or aggregate level of fiscal spending) generally suggest that increasing total fiscal expenditure without changing its composition fails to improve air quality (Bernauer & Koubi, 2006; Lopez et al., 2011). One interpretation is that the reduced pollution from raising public-good expenditure tends to be offset by the augmented pollution from increased private-good expenditure (Lopez et al., 2011).[2] An alternative argument is that government expenditure may grow for reasons other than externality correction and public-good provision, such as bureaucratic inefficiency and corruption that can even exacerbate air pollution (Bernauer & Koubi, 2006). Nation-level evidence shows that reallocating government spending in favor of public goods tends to have desirable impacts on pollution mitigation. By employing a 15-year panel of 38 countries, Lopez et al. (2011) reports a 10% increase in the share of expenditures on public goods can reduce the SO_2 emission by 4% and the lead concentration by 7%. Using a 20-year panel of 77 countries, Halkos and Paizanos (2013) claims a negative composition and technique effect without explicitly measuring education and R & D spending.

This study intends to contribute to the existing literature by first investigating the existence and magnitude of composition and technique effect at city-level, with direct measurements of education spending and R & D spending. We use data from 284 Chinese cities within the period of 2003–2012 for empirical illustration, while the combination of fiscal decentralization, regional heterogeneity and environmental diversity in China provides us with sufficient data variation. Our findings show trivial composition effect and technique effect in urban China, with the former slightly stronger than the later. Regional analysis demonstrates that the response of air pollution towards education and R & D spending diminishes from coastal area to inland area. The results remain robust when we switch between three types of air pollution measurements, confine the sample to regional central cities, instrument endogenous covariates, and incorporate spatial lags to account for potential locational spillovers. We further provide both supply-side and demand-side interpretations for the underlying mechanisms that yield the weak effects of interest.

The rest of the paper is structured as follows. Section 2 presents an optimal control framework that produces relevant comparative-static hypotheses. Section 3 describes the data and empirical modeling strategies. Section 4 proceeds to the demonstration of empirical results. Section 5 discusses potential mechanisms. Section 6 concludes.

2. Conceptual framework

The seminal Keeler, Spence, and Zeckhauser (1971) study recognizes that pollution control has strong intertemporal aspects, and recommends the use of dynamic control approach in theoretical modeling. We do not deviate from their proposal and describe the control of air pollution as a dynamic optimization problem in this study.[3] The model is constructed based upon the neoclassical Solow-Swan model of economic dynamics and the aggregate economy-environment interaction model described by Hritonenko and Yatsenko (2013), with modifications that account for the effect of public-good fiscal spending.

A social planner maximizes a social utility function by allocating final output across consumption, investment and fiscal spending on public goods, within a finite period of time.[4] A social utility function $U(C(t), P(t))$ is set to be additively separable in the utility of consumption C and the disutility of air pollutant emission P:

$$U(C,P) = \ln C - \varphi\frac{P^{1+\gamma}}{1+\gamma} \tag{1}$$

$\ln C$ is a standard logarithmic utility function, and $\frac{P^{1+\gamma}}{1+\gamma}$ (with $\gamma > 0$) is a power utility function, both satisfying Inada conditions. $\varphi > 0$ represents the societal tolerance towards pollution. Following the conventional Solow-Swan setting, P is modeled to be increasing in output Q and decreasing in public-good fiscal spending F, with Q being produced by a neoclassical Cobb-Douglas production process using physical capital K as the sole variable input (assuming fixed labor-supply):

$$P(t) = Q(t)/F(t) = SK^{\alpha}(t)/F(t) \tag{2}$$

where $1 < \alpha < 0$. S stands for the adopted technology. The associated current-valued objective function can thus be written as

$$\underset{C,I\geq 0}{Max}\int_0^T e^{-rt}\left[\ln C - \varphi\frac{(SK^{\alpha}/F)^{1+\gamma}}{1+\gamma}\right]dt \tag{3}$$

[2] Lopez and Galinato (2007) proposes the taxonomy that divides fiscal expenditure into “expenditures on public goods” that correct for certain market failures (such as subsidies on education, research and development, environmental protection, transfer payments and other conventional public goods), and “expenditures on private goods” allocated to industries that are not privately under-invested.

[3] Our model share some similarities with the Keeler et al. (1971) model in terms of basic settings, including the form of social welfare function and constraints associated with utility maximization, but significantly differs from it by incorporating technological change and fiscal spending.

[4] We model the problem as a finite-horizon mainly because of the fixed tenure system for government officials in China (10 years for two consecutive appointments, at most). The ending point of local policy planning usually coincides with the resignation of the person in charge. The Solow-Swan model considered on a finite horizon is also known as the Solow-Shell model.