Environmental governance with Chinese characteristics: are environmental model cities a good example for other municipalities?

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Abstract

Model programs such as the ‘environmental protection model city’ have become an inherent part of China’s urban environmental governance. The role of these incentive schemes for promoting best practice, however, has been neglected so far. In this study, we show that model city programs raise the bar in terms of environmental standards. What is more, model cities have a positive impact on regional economic development. We deploy a spatial Durbin model to measure best practice diffusion among 126 key environmental protection cities between 2009 and 2012. The results suggest that environmental model cities are better performers on average. We also find evidence for a positive spillover effect. Diffusion patterns are multi-layered where economic proximity is the most important dimension, followed by physical colocation and administrative hierarchy.

Keywords Environmental governance · Model cities · China · Best practice · Spatial Durbin

JEL Classification H77 · P25 · Q58 · R58

1 Introduction

China’s unprecedented history of high growth for more than three decades took its toll on the environment, ecosystem services, and human health. Public outrage about air, water, and soil pollution considerably increases political pressure to react (Li et al. 2012). Proponents of the ‘Environmental Kuznets Curve’ (EKC) posit that

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economic modernization will eventually lead to a better balance between economic and environmental interests (Grossman and Krueger 1991). A row of empirical studies confirms this proposition for the case of China (Brajer et al. 2011; Song et al. 2008; Lee and Dae-Won 2015). Institutional perspectives corroborate the EKC's predictions. Carter and Arthur (2013), for instance, find China's environmental governance principles underwent a fundamental transition from a command- and control-based system with fixed targets towards a more open management style that seeks to integrate various stakeholder groups and promote sustainable economic development. Yet implementation on the ground is often weak since many regions rely on tax income from industries incommensurate with Beijing's top-down sustainability rhetoric (Tan 2014). What is more, there seem to be ambiguous political incentives for local cadres to improve environmental performance within their jurisdictions (Wu et al. 2013; Lo et al. 2012).

Despite a lack of strong incentives to prioritize environmental protection over economic growth, local policy innovations in the field of sustainability still can have a significant impact if Beijing recognizes them as examples worth learning from. In fact, since the 1980s, the Chinese Central Government created various incentive schemes with the aim to systematically and concurrently promote innovative approaches for protecting the urban ecological environment (Zhao 2011). In this context, programs such as the 'civilized city', 'environmental protection model city', 'garden city', 'ecological garden city', or 'eco-city' have become an inherent part of China's urban environmental governance. The role of these policy incentive schemes for promoting best practice, however, is only partially understood.

Previous studies have been concerned with model cities as innovative spaces and experimentation zones for best practice. In this context, a normative literature strand evaluates criteria qualifying model cities in relation to the proposed aims (Yu 2014; Chen and Gao 2011; Chen et al. 2010; Li and Higgins 2013). This vein provides recommendations how to better align requirements, selection processes, and monitoring, with the overall policy aim. A second branch deals with political entrepreneurialism as a driving force for municipalities' environmental commitment. Case studies show that local political leaders mobilize time and resources if they sense political career opportunities or potential economic benefits (Li et al. 2011; Van Rooij et al. 2013). Besides model creation, the politics of modelling is supposed to create externalities such as the emulation of the model, imitation and repetition of the model, and encouragement by the model to try something new (Hoffman 2011). This process of learning from others is often triggered by peer pressure or orders from superiors, which raises the question whether local governments' practices of imitation are genuine or merely aim at pretending to be committed.

There is a void of research analysing model cities' influence on the diffusion of best practice and as a benchmark for regulatory compliance. In the here-presented study, we seek to address this issue. In Sect. 2, we introduce our empirical case, namely the National Environmental Protection Model Cities Program (NEPMCP), and in Sect. 3 we derive our hypotheses. Section 4 outlines our model and estimation strategy. We then present variables and data in Sect. 5, results in Sect. 6, and conclude with Sect. 7.

2 Empirical context

Models as a means of social control and device for moral education are part and parcel of Chinese socialist ruling technologies. Similar to the stylised model workers Stakhanov and Morozov in the USSR, China propagated worker heroes representing fundamental moral attributes such as selfless dedication to the building of socialism and unquestioning loyalty to the state (Sheridan 1968; Feldman 1989). Since the 1990s, the focus for model campaigns has shifted from individuals to geographical spaces; in particular villages, and cities. An early example of such spatial model scheme is the National Environmental Protection Model Cities Program (NEPMCP) launched in 1997. The underlying political imaginary dates back to the 1980s when the concept of ‘two civilisations’ sought to rebalance economic and social development by maintaining high growth on the one hand, i.e. material civilisation, and upholding moral health through spiritual civilisation construction on the other (Dyner 2008). A realm were contradictions between economic development and moral virtues became a particularly pressing concern was the natural environment, as the pursuit of material gain increasingly contributed to human misery of those affected by ecological degradation, and chemical intoxication.

The search for a model that demonstrated the virtues of accommodating economic progress in tandem with a clean and healthy environment led to Zhangjiagang, a third-tier city with about 1.3 million inhabitants in Suzhou Prefecture, Jiangsu Province. Qin Zhenhua, the city’s Party Secretary between 1992 and 1998, got inspired by Singapore’s ‘Garden City’ approach and decided to make Zhangjiagang the cleanest city in China. Qin’s foremost aim was not only to attract foreign direct investment but also to profile him as a progressive and visionary leader. In 1995, the provincial propaganda department used Zhangjiagang as a model unit for General Secretary Jiang Zemin’s two civilizations. A provincial meeting was held in the city and word was spread to Beijing. Jiang himself visited Zhangjiagang and wrote sixteen characters known as the ‘Zhangjiagang spirit’ (Zweig 1997).

Zhangjiagang offered the right moral values but the environmental agenda was not very elaborate. The actual content for the NEPMCP originates from the ‘Japan–China Environmental Development Model City Scheme’. Enacted in 1997, this program benefited from foreign funds and technology to boost the environmental performance of three Chinese cities: Dalian, Chongqing, and Guiyang (Baker 2015, 410). Under the influence of transnational cooperation, a model agenda emerged that rested on market rationalities and quantitative ways of evaluating environmental performance (Hoffman 2009, 113). Model cities were gradually calibrated to promote an environmental performance profile that rests on a comprehensive indicator system called the Quantitative Examination System on Comprehensive Control of the Urban Environment and a second set of variables measuring economic and social development (Li et al. 2011).

To promote the model city program, a standardized assessment plan was developed and application for the model program became open for all cities and

districts. Today, the assessment comprises of three basic conditions and 23 specific targets under four categories, namely socio-economic standards, environmental quality, environmental construction and environmental management. To attain national model city status, a municipality must conduct self-assessments and implement a local plan in line with the Ministry of Environmental Protection's (MEP) requirements. In particular, a city needs to

- achieve national and provincial pollutant control tasks;
- be among the top-ranking cities for overall environmental performance in the province for three consecutive years;
- have no serious environmental incidents in the urban districts during the past 3 years, and no violations of environmental regulations the past year;
- develop an environmental emergency plan (MEP 2011).

Moreover, if a city meets the MEP's requirements and submits its report to the provincial Environmental Protection Bureau (EPB) and the MEP, the city needs to follow a public notification rule. During the process, the MEP conducts evaluations and site visits before assessment reports are made available to the public for feedback. The detailed performance criteria for becoming an environmental model city are listed in Table 1.

The process of becoming a national model city takes 3–4 years (Li et al. 2011). Model cities are required to report their progress to the provincial EPB each year and be re-evaluated by the MEP every 3 years to maintain their status. Failing to meet the benchmarks of the NEPMCP may theoretically result in the loss of the title; even though in practice this case never happened. As of April 2012, 78 cities and 6 urban districts across China were awarded the title. More than two-thirds of the cities (58/84) are located in developed regions along China's East Coast, with 21 in Jiangsu, 20 in Shandong, 10 in Guangdong and 7 in Zhejiang. The following section will show that, despite comprehensive assessments, model cities are not always the vanguard of environmental protection. Yet little is known to what extent bad examples are representative for the entire body of environmental model cities, and, to the best of our knowledge, there were no attempts to measure the learning or spillover effect from model cities to other municipalities.

3 Hypotheses

The mainstream of studies on China's economic reforms holds the view that Leninist means of control, in particular the Communist Party's nomenklatura system, is the single most important institution shaping local cadres' behaviour (Burns 2017; Brødsgaard 2002; Huang 1995). Leading politicians in a jurisdiction are evaluated by their superiors once a year based on a performance catalogue with hard targets and soft targets (Edin 2003). Compliance with these benchmarks is a decisive factor for career opportunities and financial bonuses. The so-called cadre evaluation system represents an effective means to implement central policies and divide responsibilities between jurisdictions and/or departments. In this context, economic growth

Table 1 National model city for environmental protection assessment indicators. Source: Authors' compilation based on MEP (2011)

Basic requirements

1. Fulfil the main national and provincial pollutant control tasks
2. No serious environmental incidents in the urban districts during the past 3 years, no violations of environmental regulations in the past year; and the development of an environmental emergency plan
3. Among the top ranking cities for overall environmental performance in the province for three consecutive years

Economic and social

4. Annual per capita disposable income of urban residents 10,000 RMB, and 8500 RMB for cities in western China in the past three years; environmental spending > 1.7% GDP
5. Energy consumption per unit of industrial added value is declining year by year
6. Declining water consumption per unit of GDP
7. Major industrial pollutants emission intensity per unit of industrial added value is declining year by year

Environmental quality

8. The annual average concentration of major pollutants in urban air meet national standards; 85% of the total number of days per year meet the daily average concentration of pollutants in the secondary standard
9. Compliance with central quality standards in drinking water source areas.
10. Achieve environmental functional requirements of water quality within the jurisdiction, and at the cross-section of the city's domain exit meet the transregional water quality requirements
11. Urban environment noise level < 60 dB(A)
12. Traffic noise level < 70 dB(A)

Environment construction

13. > 35% of the total area in the green area (per capita green area above the national level for cities in western China)
14. > 80% of urban wastewater treated, > 20% of urban sewage water recycled
15. Key industrial enterprises stabilize emissions standards
16. > 50% of total energy consumption is clean energy use
17. > 80% of motor vehicles inspected for environmental standards
18. > 85% of urban garbage treated for environmental standards
19. > 90% of industrial solid waste treated or reused
20. Safe disposal of hazardous waste in accordance with law

Environmental management

21. Environmental Protection target responsibility system in place. Environmental indicators have been included in the party and government leading cadres Ministry of performance evaluation. Governmental officials assigned responsibilities to implement environmental quality public announcement system
 22. Implementation of the EIA law for new projects
 23. Environmental Protection Agency an independent institution. Environmental capacity building to meet national standardized building requirements
 24. Public satisfaction rating for urban environmental protection > 80%
 25. Environmental education integrated into primary and secondary school education > 85%
 26. Implementation of urban environmental sanitation and meet the requirements of environmental management for surrounding areas
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and attracting investments have been hard performance targets for at least 2 decades while environmental goals only recently gained currency (Heberer and Trappel 2013). Yet, the underlying logic of economic development first remains even though its pursuit has to evolve under increasingly explicit environmental constraints.

Attaining model city status is not part of the regular cadre evaluation but it is shaped by the same Leninist institutions. In this context, it is important to note that cadres operate under a limited time horizon of 3–4 years due to the cadre rotation system (Eaton and Kostka 2014). Local leaders, therefore, will opt for measures that show fast results, which is not always conducive for sustainable environmental protection (Ran 2013). Consequently, the academic literature offers cursory evidence for both positive contributions to—as well as negative departures from—the environmental model city program. Li and Higgins (2013), for example, suggest that an application for model city status enhances local officials bargaining power to advance a green agenda. Model city status may also enhance a local leader's odds to be promoted. What is more, many city officials regard a model city title as an effective place marketing tool in an attempt to attract investors, professionals, and tourists (Chung 2015). Reportedly applying for the title is also used to raise environmental awareness and mobilize the public as in the case of Jiaying where officials sought to engage residents in building an energy-saving and environment-friendly society (Weiyi and Xing 2009). Finally, model cities may open the stage where municipalities can showcase innovative achievements and develop new business models. For instance, Rizhao actively promotes solar technologies by regularly holding education fairs and exhibitions, encouraging solar manufacturers to show their products (Kwan 2009).

On the flip side, environmental model cities can turn into expensive projects with little value or even negative impact for environmental protection. Ren (2012) observes that model cities are invariably led by the central state or local state in collaboration with international experts and with little grassroots input. Model cities exhibit clear tendencies toward spectacularisation. Eagerness to instigate fast progress often leads to perverse effects where eco-systems are destroyed to make room for more exotic or aesthetically appealing vegetation, and mature trees are transplanted from distant forests to municipalities' barren lands (Chung 2015). Also, ecological objectives are regularly used to legitimize land expropriation and increase the value of real estate. From this perspective, model city building is closely connected to land-financed economic development of urban spaces (Shiuh-Shen 2013). The rural population might not only become victim of model cities land hunger but also the recipient of polluting industries that are relocated to clean up the city centre. According to Liu (2013), this practice has serious consequences as there is a tendency that cancer villages, i.e. rural settlements with a particularly high rate of cancer patients, are in many instances collocated with environmental model cities. Despite these caveats, we can hypothesize from a normative perspective that

H1 On average, model cities perform better in terms of environmental protection relative to other (comparable) municipalities.

The politics of modelling is supposed to induce an imitation effect. Model emulation, in this context, is orchestrated within the ministerial bureaucracy that selects the municipalities that are supposed to learn from model cities. With

Fig. 1 Model- and key environmental protection cities. Source: Authors' map based on information retrieved from <http://www.ipe.org.cn/> and http://english.mep.gov.cn/inventory/Model_cities/

respect to environmental protection, the MEP maintains a list of 'key environmental protection cities (KEPC)'. KEPCs have a special obligation to take the lead in implementing environmental policies and are subject to comprehensive monitoring (Wang et al. 2013; Liu and Wang 2013; Marquis et al. 2011). Being listed as a key environmental protection city is not at the discretion of a municipality whereas participating in a model city program is voluntary. Thus, requirements for model cities usually go beyond the benchmarks that apply to KEPCs. Consequently, learning effects are expected to flow from model cities to KEPCs and the latter, in turn, transmit best practice to lower tier cities. Figure 1 depicts the location of all key environmental protection cities in orange, and those with model city status are marked in white. Obviously, most model cities are located along the wealthy East Coast with focal clusters in Jiangsu, Zhejiang/Shanghai, and Guangdong. Yet more recent additions emerged in the Western and Central regions. As a result, there is a net of demonstration points emerging, which may bring best practice to other key environmental protection cities. In this study, we will analyse spatial interdependence within this particular web of strategic cities. We hypothesize

H2 Model cities have a positive impact on environmental protection performance of other key environmental protection cities.

4 Model and estimation strategy

4.1 Model

Emulation of model cities rests on regionally/locally embedded policies and thus considering a spatial econometric approach to test our hypotheses seems to be in order. In the following sections, we elaborate the case of a panel fixed effects model because our data are time variant and comprise of 126 Chinese cities with heterogeneous background variables. The general static spatial model is

$$Y_t = \alpha_{iN} + \rho WY_t + \beta X_t + WX_t\theta + \mu + \xi_i i_N + u_t, \quad \text{where } u_t = \lambda Wu_t + \varepsilon_t$$

with cities $i = 1, \dots, N$; time $t = 1, \dots, T$, and $k = 1, \dots, K$ exogenous explanatory variables, i_N is an $N \times 1$ vector of ones that are related to the constant term parameter α , and the time parameter ξ , Y denotes an $N \times 1$ outcome indicator representing observations on the dependent variable; X is an $N \times K$ matrix of exogenous explanatory variables associated with β , which represents a $K \times 1$ vector of parameters. W is a nonnegative $N \times N$ matrix of defining the type and degree of neighbourhood in the sample. The diagonal elements are zero because no unit can be its own neighbour. WY denotes the endogenous interaction effects among the dependent variables and WX represents interaction effects among the independent variables. Wu describes interaction effects among the disturbance terms. ρ represents the spatial autoregressive coefficient, λ the spatial autocorrelation coefficient, while θ is a $K \times 1$ vector of fixed but unknown parameters.

$\varepsilon = (\varepsilon_1, \dots, \varepsilon_N)^T$ is a vector of disturbance terms ε_i which are independently and identically distributed for all i with zero mean and variance σ^2 . $\mu = (\mu_1, \dots, \mu_N)^T$ are city fixed effects that account for omitted diversity factors. Finally, superscript T denotes the transpose of the vector matrix.

In the above model, spatial interdependence can emerge along three autoregressive processes (Manski 1993):

1. Endogenous interaction where the outcome variable at one location is dependent on outcomes in other places. This is the case when $\rho \neq 0$.
2. Spatial error correlation as the result of unobserved geographical interdependence. This is the case when $\lambda \neq 0$.
3. Exogenous interaction, which refers to the spatial spillover effects from explanatory factors in one location towards outcomes in other places. This is the case when $\theta \neq 0$.

4.2 Estimation strategy

In a first step, we define concepts of proximity with a spatial weight matrix W where the distance between two cities i and j is normalized so that $0 \leq W_{ij} \leq 1$ and $W_{ij} = 0$ if $i = j$. We row standardize matrix W , i.e. $\sum_j W_{ij} = 1$ for $i = 1, \dots, N$. To determine an appropriate model specification, we follow the estimation strategy of Elhorst (2010) who proposes to begin with a spatial Durbin model (SDM). The SDM represents

the case where $\rho \neq 0 \wedge \theta \neq 0 \wedge \lambda = 0$. We then consider a potential reduction of the SDM towards a Spatial Autoregressive Model (SAR) where $\rho \neq 0 \wedge \theta = 0 \wedge \lambda = 0$ or a Spatial Error Model (SEM) if $\rho = 0 \wedge \theta = 0 \wedge \lambda \neq 0$. The robust Hausman test is deployed to decide upon the need to include city-fixed effects. Estimates are carried out with the `xsmle` command for Stata (Belotti et al. 2017). Elhorst (2010) presents the ML estimator in the context of a spatial lag model and error model with fixed or random effects. He notes that also the spatial Durbin model can be estimated as a spatial fixed effects model. However, Lee and Yu (2010) find that the ML estimator of the spatial lag and the spatial error model will yield an inconsistent parameter estimate of the variance parameter if N is large and T is small. As this is the case for the here-presented empirical study, we deploy the bias correction procedure of Lee and Yu (2010).

4.3 Model interpretation

In this study, we are not only interested in the relative performance of model cities but also in the spillover effects towards other municipalities. To render the estimates of the spatial model interpretable in this context, we deploy the method described in LeSage and Fischer (2008), which separates the elasticity θ of WX_t into a direct and indirect effect. To illustrate this approach, consider the SDM in a slightly different notation where we move ρWY_t to the left-hand side; I_N represents the identity matrix.

$$(I_N - \rho W)Y_t = \alpha_{I_N} + \rho WY_t + \beta X_t + WX_t\theta + \mu + \xi_t I_N + \lambda Wu_t + \varepsilon_t.$$

Eliminating $(I_N - \rho W)$ on the left-hand side yields:

$$Y_t = (I_N - \rho W)^{-1} \alpha_{I_N} + (I_N - \rho W)^{-1} \beta X_t + (I_N - \rho W)^{-1} WX_t\theta + (I_N - \rho W)^{-1} \xi_t I_N + (I_N - \rho W)^{-1} \lambda Wu_t + (I_N - \rho W)^{-1} \mu + (I_N - \rho W)^{-1} \varepsilon_t.$$

Taking partial derivatives of y for the k th independent variable X across $i = 1 \dots N$ cities at time t results in (LeSage and Pace 2009, 74)

$$\left[\frac{\partial Y}{\partial x_{1k}} \dots \frac{\partial Y}{\partial x_{Nk}} \right]_t = (I_N - \rho W)^{-1} (I_N \beta_k + W \theta_k).$$

The partial derivatives for the expected outcome of y , i.e. we ignore white noise, can be represented in matrix form as

$$\left[\frac{\partial Y}{\partial x_{1k}} \dots \frac{\partial Y}{\partial x_{Nk}} \right]_t = (I_N - \rho W)^{-1} \begin{bmatrix} \beta_k & w_{12}\theta_k & \dots & w_{1N}\theta_k \\ w_{21}\theta_k & \beta_k & \dots & w_{2N}\theta_k \\ \vdots & \vdots & \ddots & \vdots \\ w_{N2}\theta_k & w_{N2}\theta_k & \dots & \beta_k \end{bmatrix},$$

with w_{ij} being the (i, j) th element of W . The partial derivative matrix brings to the fore that a unit change of any independent variable in any city, will alter the

dependent variable of that municipality (direct effect), i.e. the diagonal elements of the matrix, as well as the dependent variable of other cities (indirect effect), i.e. off-diagonal elements of the matrix. Disentangling direct and indirect effects is of particular interest for interpreting the results of this study. What is more, this exercise improves the validity for detecting spillover effects as compared to relying on point estimates of λ (SEM), ρ (SAR/SDM) or θ (SDM) (LeSage and Pace 2009, 74).

The partial derivatives matrix illustrates why the SDM is particularly relevant for our analysis. Direct effects change because the diagonal elements of the matrix are different for each municipality if $\rho \neq 0$. The indirect effects vary because the off-diagonal elements of W are different for each city given that $\rho \neq 0$ and $\theta \neq 0$ (Elhorst 2014). When we reduce the SDM towards a SEM then $\rho = 0$ and $\gamma = 0$. As a result, there will be no indirect or spillover effects because all off-diagonal elements equal zero. In a SAR model, the ratio between the estimated indirect and direct effects, i.e. off-diagonal and diagonal effects $(I_N - \rho W)^{-1} \beta_k$, respectively, will be constant as β_k in the nominator and denominator cancel each other out. This means that each independent variable is bound to the same ratio, which is determined entirely by ρ and W (Elhorst 2014). Thus, interpreting the spillover effects derived from a SAR model needs to be done with care due to constrained assumptions.

4.4 Spatial neighbourhood definition

Incentives for attaining model city status as well as emulating model cities are embedded in the political economy of Leninist cadre management. We, therefore, would expect spatial spillover effects to evolve along these lines. Heilmann (2008) generalized the Chinese Central State's Leninist approach to policy innovation and implementation with the concept 'experimentation under hierarchy' (Heilmann 2008). The concept gained wide currency in recent years and has been applied successfully to explain policy-making fields (Tsai and Dean 2014; Wang 2009; Ahlers and Schubert 2013; Xia and Pahl-Wostl 2012). Experimentation under hierarchy proposes that to climb up the career ladder, a political leader needs to distinguish herself from competing peers with an innovative policy approach or model. If the cadre succeeds in standing out she will seek to gain support and encouragement from higher level political sponsors. After a powerful policy-maker has endorsed the results of a successful approach, campaigns and lobbying are needed to broaden support for the initiative and eventually diffuse the successful approach as a model for a wider region or even the whole nation (Heilmann 2008). Attaining model city status can be framed within this concept. In a first step, a city will have to demonstrate that it disposes of the necessary credentials, i.e. it needs to perform better than comparable cities. The ambition to apply for model city status, however, requires endorsement from superiors. In this vein, Miao and Lang (2014) show that local innovation efforts with the aim to promote environmental demonstration zones rely on higher level political patronage to advance. Finally, the model city will invite other city officials for study visits to promote the emulation and thereby render the model policy relevant in a broader context. We propose that these three stages of

the model creation and diffusion process evolve along three different spatial scales, namely regionally, within Provinces, and within economic income groups.

Proposition 1 Model cities have a positive impact on environmental performance of municipalities in the same region.

We seek to approximate proposition 1 with a geographic proximity matrix. We deploy an inverse distance matrix with a cut-off point at 300 km. We chose a 300-km band to ensure that all but two remotely located cities have at least one neighbour. The results, however, are not sensitive to this choice. The cut-off serves two purposes. On the one hand, it mirrors China's vast economic divergence and differences in political priorities. For example, Shanghai and Hangzhou are two economically well-endowed cities that are connected with a 170-km high-speed rail. We, therefore, would expect that these cities are mutually aware of their respective environmental achievements and may see the necessity for strategic positioning. At the same time, leaders from Shanghai probably will not compare their approach with Karamay in Xinjiang, which is located 4000 km away, heavily controlled by the Chinese military, and mainly relying on natural resource exploitation. The second reason for a cut-off is a technical one. Because we are using an inverse distance matrix, we need to make sure that the correlation between two spatial units converges towards zero (Elhorst 2010). In this context, a cut-off point will bind row and column sums of the matrix in absolute value before row-standardization.

Proposition 2 Model cities have a positive impact on environmental performance of municipalities in the same Province.

Environmental governance in China crucially relies on implementation efforts along the horizontal administration line from the Central Government to the Provinces and Autonomous Regions, down to the village or neighbourhood level (Lieberthal and Oksenberg 1988). Provincial governments coordinate all efforts within their jurisdictional borders and they may also draft the visions, standards, and incentives that will shape environmental protection at the city level. Thus, the learning effect might be something that is particularly strong or even confined to administrative borders at the provincial level. For example, local cadres in Hangzhou may benchmark their environmental commitment against policies in Ningbo because they compete for political acknowledgement from their superior, the Provincial Government of Zhejiang. By contrast, under administrative proximity the Local Government in Hangzhou will not seek to emulate Shanghai's environmental policies because there is no administrative tie between them. We capture these spillover effects with a binary contiguity matrix where cities of a province are defined as neighbours. This specification leaves four provincial-level municipalities Beijing, Tianjin, Chongqing, and Shanghai without any neighbours. Note that the results remain robust when we exclude these locations from our estimation.

Proposition 3 Model cities have a positive impact on environmental performance of municipalities with the same level of economic development.

Li and Higgins (2013) point out that the environmental model city program in China represents a scheme that seeks to stimulate local political commitment amidst vast economic disparities. From this point of view, standards and best practice may be a matter of economic development rather than physical proximity. In other words, local leaders in relatively poor cities may want to learn from model cities with a

similar level of economic development because economic peers are more likely to tackle similar problems and face comparable budget constraints. We seek to capture this developmental interpretation of best practice diffusion with an economic distance matrix where proximity is defined by income quartiles. Thus, the economic distance matrix investigates whether poor KEPCs learn from poor model cities while rich municipalities learn from wealthy model cities. Quartile calculations are based on average per capita gdp during the sample period. Our economic neighbourhood definition is broader than the other two approaches and consequently there are no locations left without a peer.

5 Variables and data

5.1 Dependent variables

We look at key performance indicators that relate to the qualification criteria for environmental model cities as listed in Table 1. In particular, we deploy publicly available indicators and statistics on environmental management, and pollution.

Air quality (hard targets): environmental protection is gradually emerging as a major evaluation criterion for local officials at the sub-national level (Heberer and Trappel 2013). In this context, air quality has become a particularly important area of social and political concern. Reducing SO₂ emissions was already a hard target during the 11th Five-Year Plan, 2006–2010 (Gao et al. 2009), while particulate matter (PM10 and PM2.5) became a focal point since the Olympic Games in Beijing in 2008 (Zhang et al. 2010). In addition, widespread social media protests since 2011 enhanced political efforts to monitor air quality (Fedorenko and Sun 2015; Kay et al. 2015). We measure statistics on SO₂ and PM10 treatment (achievement) relative to assigned municipal targets (political benchmark) to embed them into the political economy of performance evaluation. Statistics on particulate matter and sulphur dioxide are measured in metric tonnes per 1000 inhabitants.

Enforcement of environmental transparency regulations: We approximate environmental management performance with the Pollution Information Transparency Index (PITI), which measures a city's compliance level with the MEP's Measures on Open Environmental Information (MOEI). The regulations require that local governments disclose information within six areas: environmental laws and regulations, allocation of emission quotas, pollution fees collected, grace periods and exemptions granted, outcomes of investigations into public complaints, and corporate violations of environmental regulations. The maximum achievable PITI score is 100, and 60 is defined as the threshold for basic compliance.

To get a better understanding of model cities' particular achievements, we compare model cities with KEPCs. In Fig. 2, we depict our dependent variables with boxplots and compare variations between and within each of the two groups (model cities and other cities). The 'whiskers' above and below the box show the locations of the minimum and maximum. The central rectangle spans the range from the first to the third quartile (interquartile range, IQR) and the horizontal line within the box marks the median, i.e. a typical value for a representative of

Fig. 2 Boxplots for dependent variables

each group. Finally, the dots depict outliers, which are defined as values three times (or more) above or below the IQR. Figure 2 suggests that model cities on average are performing better with respect to environmental indicators. The largest difference pertains to environmental management capacity (approximated with the PITI) while differences in sulphur dioxide control are marginal only. Still the bottom quartile of model cities is usually performing worse than the top quartile of other KEPCs. Hence, learning effects are not likely to flow from any model city to any other city, which supports our approach to consider different spatial weight conceptions.

5.2 Independent variables

Model city status: We measure model city status with a dummy variable that takes on the value of 1 if a city holds the award at time t and 0 otherwise.

Other control variables: There is a widely shared belief that the level and sophistication of environmental protection increases with economic development (Stern 2004). In China, where income disparities are large and budgetary responsibilities decentralized, this factor may play a particularly important role. This is in line with several empirical studies on China finding a significant positive association between air pollution and the level of income (Brajer et al. 2011; Song et al. 2008; Lee and Dae-Won 2015). We, therefore, include gdp per capita as a control variable. In addition, we include the number of residents in a municipality because key environmental protection cities vary in size, which may have repercussions on the type of issues emerging and the capacity to tackle them.

The root cause of environmental degradation in China pertains to the pursuit of economic growth at any cost driven by political and economic elites that benefited disproportionately from local economic development since the mid-1990s (Nee 1991; Walder 1992; Zhou and Logan 1996). During that time, economic growth emerged also as a key performance indicator for the evaluation of cadres at the sub-provincial level (Edin 2003). Also, economic growth figures serve as a key indicator for the CCP's performance legitimacy bolstering its power monopoly (Zhu 2011). To account for this fact, we use economic growth calculated as the year on year percentage change of total gdp.

The low priority of environmental goals in local leaders' policy agenda is also a result of tightening budget constraints and the rising amount of unfunded mandates, i.e. political, social, and bureaucratic assignments that the Central State hands down to sub-national echelons without providing budgetary funding for fulfilling them (Ong 2012). Revenue-expenditure gaps are particularly severe at the sub-provincial level (Brehm 2013) and thus cities may vary a great deal in terms of their financial capacity to implement and enforce environmental protection measures. The main budgetary income sources for local governments in China come either in the form of taxes, mainly value-added and business tax, or directly as income from government-owned enterprises (Tsui 2005). We approximate a municipality's fiscal constraint as the ratio between budgetary income and corporate value-added. In the analysed

Table 2 Descriptive statistics

Variable	Obs	Mean	SD	Min	Max	Share of missing values
SO2	367	1.45	1.62	0.10	15.01	2.39
PM10	367	77.54	72.50	1.51	736.04	2.39
PITI	347	39.72	16.72	12.00	85.30	7.71
Model city	376	0.25	0.43	0.00	1.00	0.00
GDP (pc)	372	116.37	139.71	10.25	960.87	1.06
Population	372	518.56	367.04	38.43	3289.53	1.06
Growth	375	13.93	2.61	1.20	25.80	0.27
Budget	361	1.90	5.35	0.09	100.27	3.99

context, a rising ratio points towards increasing difficulties to mobilize additional financial resources for environmental fixes. We provide summary statistics on all variables in Table 2.

5.3 Data

Our data sample comprises of 126 key environmental protection cities and model cities for the time period 2009–2012. Data originate from three sources: The PITI reports for the years 2009/2010, 2011, and 2012 are available at the Institute of Public and Environmental Affairs.¹ We retrieved information on model city status from the MEP homepage.² Control variables are taken from various issues of China City Statistical Yearbook.

The descriptive statistics in Table 2 show that there are missing values in the range of 0.2–7.7% of total observation points. For spatial analysis, however, a panel has to be strongly balanced. We, therefore, impute missing values with a multivariate normal regression and generate ten complete data sets (Rubin 1977, 2004). The procedure to approximate the distribution of missing data is a Bayesian iterative Markov chain Monte Carlo approach. Spatial analysis is then performed on each of the ten imputed complete datasets. The final point estimates are averages of the parameter values generated by the ten imputations.

6 Results

6.1 Model selection and comparison

To determine the most suitable model specification, we follow the selection strategy proposed in Elhorst (2010). We estimate a spatial Durbin model and use subsequent

¹ <http://www.ipe.org.cn/> (accessed 2016-06-07).

² http://english.mep.gov.cn/inventory/Model_cities/ (accessed 2016-06-07).

Table 3 Correlation matrix and variance inflation factors (VIF)

	PITI	PM10	SO ₂	Model city	GDP (pc)	Population	Budget	Growth	VIF
PITI	1.00								
PM10	0.11	1.00							
SO ₂	0.15	0.31	1.00						
Model city	0.35	0.16	0.19	1.00					1.1767
GDP (pc)	0.32	0.11	0.32	0.26	1.00				1.3916
Population	0.16	0.06	0.18	0.06	0.35	1.00			1.1883
Budget	0.35	0.15	0.17	0.32	0.23	−0.08	1.00		1.1397
Growth	−0.15	−0.15	0.04	−0.02	0.32	0.21	0.01	1	1.1795

likelihood ratio tests for the hypotheses $H_0: \gamma=0$ and $H_0: \gamma+\rho\beta=0$. The spatial Durbin model can be reduced towards a spatial lag model if we cannot reject the former hypothesis and into a spatial error model if the latter holds true. Tables 4, 5 and 6 show that we consistently can reject both null hypotheses except for Table 4: INV3 (sulphur dioxide) where we deploy an inverse distance matrix. A LM test for general autocorrelation was significant at the 5% level, which justifies including the results for comparison.

We use a robust Hausman test to decide upon the inclusion of city fixed effects as a precaution to avoid an omitted variable bias. The results in Tables 4, 5 and 6 suggest that there are only two specifications where random effects constitute a feasible option (Table 4: INV2, Table 5: PROV3). To keep the results comparable, we adopted a city-fixed effects model throughout all specifications. Table 3 depicts pairwise correlations and list the variance inflation factors that we derived after estimating the spatial Durbin model. Correlations are low and the VIFs are below a critical value of 10, which suggests that we have no serious multicollinearity issue.

6.2 Model city effect

The main effects in Table 4 indicate that model cities are better environmental performers than other key environmental protection municipalities in the same region. Region is here defined with a distance band at 300 km. Thus, the results in Table 4 imply that model city status is associated with above-average commitment to mitigate environmental threats at the regional level. This insight fits into the previously outlined ‘experimentation under hierarchy’ model, which posits that local leaders compete for superiors’ attention with outstanding achievements and visions. Yet these extra efforts do not encourage or pressure municipalities in the region to learn from model cities as the indirect effect is insignificant. In Table 5 we compare model cities and other key environmental protection cities within provincial boundaries. The main effect is insignificant. The direct model city effect, however, is significant and the coefficients are about the same size as the estimates based on the regional distance matrix in Table 4. Apparently model cities represent both local environmental champions and provincial

Table 4 Spatial regression with inverse distance matrix

	Main effect				Direct effect				Indirect effect			
	INV1 PTI (t)	INV2 PM10 (t)	INV3 SO ₂ (t)		INV1 PTI (t)	INV2 PM10 (t)	INV3 SO ₂ (t)		INV1 PTI (t)	INV2 PM10 (t)	INV3 SO ₂ (t)	
Model city	0.271*** (4.104)	0.533*** (2.162)	0.598*** (2.058)		0.268*** (4.834)	0.571*** (2.747)	0.587*** (2.382)		-0.051 (-0.394)	0.925* (1.749)	-0.132 (-0.204)	
P.C. GDP	0.312*** (14.582)	0.241*** (3.055)	0.107 (1.145)		0.317*** (13.348)	0.266*** (3.020)	0.126 (1.209)		0.135*** (3.716)	0.451*** (2.911)	0.248 (1.249)	
Population	-0.042 (-1.332)	0.071 (0.598)	-0.160 (-1.136)		-0.043 (-1.245)	0.096 (0.722)	-0.142 (-0.897)		-0.106 (-1.551)	0.408 (1.483)	0.176 (0.503)	
Growth	-0.002 (-0.485)	-0.030 (-1.585)	-0.008 (-0.369)		-0.003 (-0.586)	-0.030* (-1.705)	-0.010 (-0.454)		-0.018*** (-2.642)	-0.020 (-0.744)	-0.032 (-0.961)	
Budget con- straint	-0.033 (-0.556)	0.546** (2.495)	0.238 (0.917)		-0.012 (-0.201)	0.626*** (2.915)	0.359 (1.409)		0.339*** (3.083)	0.763* (1.730)	1.248** (2.274)	
ρ	0.117* (1.789)	0.203*** (3.181)	0.247*** (4.244)									
σ^2	0.026*** (13.729)	0.356*** (13.690)	0.500*** (13.672)									
N	378	378	378									
$\gamma=0$	18.43***	11.84**	6.92									
$\gamma=-\beta\rho$	22.75***	15.91***	7.39									
Hausman	17.04*	13.07	17.84*									
AIC	-286.24	710.47	840.33									

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5 Spatial regression with province weight matrix

	Main effect			Direct effect			Indirect effect		
	PROV1 PTI (<i>t</i>)	PROV2 PM10 (<i>t</i>)	PROV3 SO ₂ (<i>t</i>)	PROV1 PTI (<i>t</i>)	PROV2 PM10 (<i>t</i>)	PROV3 SO ₂ (<i>t</i>)	PROV1 PTI (<i>t</i>)	PROV2 PM10 (<i>t</i>)	PROV3 SO ₂ (<i>t</i>)
Model city	0.150* (1.880)	0.264 (0.939)	0.331 (0.988)	0.192*** (2.999)	0.588** (2.346)	0.507* (1.890)	0.149 (1.187)	1.188 (1.543)	0.625 (1.117)
P.C. GDP	0.292*** (11.730)	-0.015 (-0.165)	0.005 (0.044)	0.296*** (11.991)	0.300*** (2.948)	0.153 (1.458)	0.007 (0.182)	1.110*** (3.415)	0.483*** (2.136)
Population	0.005 (0.128)	-0.203 (-1.474)	-0.458*** (-2.777)	-0.015 (-0.463)	0.131 (0.947)	-0.185 (-1.188)	-0.077 (-1.003)	1.177*** (2.035)	0.908*** (1.996)
Growth	-0.004 (-0.670)	-0.051** (-2.280)	-0.007 (-0.276)	-0.006 (-1.094)	-0.039** (-2.084)	-0.010 (-0.424)	-0.006 (-1.048)	0.043 (1.287)	-0.009 (-0.361)
Budget constraint	-0.146** (-2.041)	0.180 (0.713)	0.125 (0.413)	-0.079 (-1.164)	0.506* (1.937)	0.364 (1.307)	0.179 (1.430)	0.983 (1.300)	0.603 (1.102)
ρ	0.296*** (33.688)	0.279*** (36.916)	0.293*** (33.468)						
σ^2	0.038*** (13.446)	0.471*** (13.121)	0.673*** (13.369)						
<i>N</i>	378	378	378						
$\gamma=0$	126.93***	64.23***	33.41***						
$\gamma=-\beta\rho$	10.47***	37.25***	22.11***						
Hausman	36.62***	-34.90***	16.84						
AIC	-204.87	764.21	885.53						

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6 Spatial regression with economic distance matrix

	Main effect			Direct effect			Indirect effect		
	ECON1 PTI (<i>t</i>)	ECON2 PM10 (<i>t</i>)	ECON3 SO ₂ (<i>t</i>)	ECON1 PTI (<i>t</i>)	ECON2 PM10 (<i>t</i>)	ECON3 SO ₂ (<i>t</i>)	ECON1 PTI (<i>t</i>)	ECON2 PM10 (<i>t</i>)	ECON3 SO ₂ (<i>t</i>)
Model city	0.271*** (3.813)	0.437* (1.766)	0.367 (1.225)	0.156** (2.544)	0.289 (1.411)	0.371 (1.461)	1.157*** (5.037)	7.270*** (3.360)	−0.120 (−0.060)
P.C. GDP	0.340*** (16.880)	0.156** (2.161)	0.145 (1.596)	0.322*** (14.378)	0.144* (1.819)	0.119 (1.175)	0.206*** (5.178)	0.847** (2.308)	0.895*** (2.598)
Population	0.018 (0.517)	0.364*** (2.559)	−0.016 (−0.101)	−0.004 (−0.136)	0.266** (2.034)	−0.069 (−0.434)	0.246* (1.852)	5.288*** (4.010)	1.770 (1.461)
Growth	0.001 (0.114)	−0.005 (−0.258)	−0.007 (−0.297)	0.001 (0.209)	−0.005 (−0.271)	−0.005 (−0.207)	−0.005 (−0.762)	0.019 (0.511)	−0.048 (−1.245)
Budget con- straint	−0.043 (−0.803)	0.376* (1.830)	0.363 (1.396)	−0.032 (−0.538)	0.386* (1.850)	0.301 (1.121)	−0.004 (−0.035)	1.639** (2.219)	3.303*** (4.684)
ρ	−3.776*** (−3.401)	−0.761* (−1.944)	−1.431*** (−2.692)						
σ^2	0.021*** (11.481)	0.307*** (13.656)	0.485*** (13.429)						
<i>N</i>	378	378	378						
$\gamma=0$	16.86***	17.95***	18.09***						
$\gamma=-\beta\rho$	22.57***	20.49***	19.57***						
Hausman	50.22***	36.72***	36.85***						
AIC	−314.90	653.46	833.3054						

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

environmental leaders, which speak to a selection mechanism based on hierarchical political endorsement. Other key environmental protection cities, however, seem not to emulate model city practices on a regular basis. At least this is what the insignificant indirect model city effect implies. The nomenklatura system, as the main Leninist incentive scheme for political leaders, offers an explanation for this finding: Political careers rely on innovative, visionary commitment in order to gain attention from upper echelons. City leaders, therefore, compete with cadres in neighbouring municipalities and within the same Province because they have the same superiors; namely Provincial party and government officials. Hence, a city leader has no desire to imitate a directly competing peers' innovations as this would enhance a rivals' achievements (being emulated) and weaken her own position (imitation instead of innovation).

The economic distance results in Table 6 provide an additional piece in this puzzle. The direct effect for all three models (Table 6), ECON1–3, is insignificant, which indicates that model cities are not necessarily national champions compared to key environmental protection cities with similar income levels. Yet, the significant main and indirect effect in models (Table 6) ECON1 and 2 gives reason to suppose that model cities have a positive impact on environmental performance of other key environmental protection cities with a comparable economic development level. Thus, the economic distance results offer some support for a positive emulation effect. The observations are in line with nomenklatura incentives because city leaders may seek to find inspiration for outstanding achievements from municipalities that are not direct political competitors. The most likely candidates to look at are model cities that face similar challenges and constraints in terms of economic development. Table 6: ECON3, which features the estimates for sulphur dioxide is not in line with this learning effect. For robustness we, therefore, looked at two additional indicators: first, wastewater discharge, measured in metric tonnes. Similar to sulphur dioxide and particulate matter, we use the wastewater target as a benchmark. Second, we approximate energy efficiency as coal consumption (measured in tonnes) relative to gdp. Both indicators show the same pattern as Table 6: ECON1 (environmental management index) and Table 6: ECON2 (particulate matter).

6.3 Spatial lag

The spatially lagged dependent variable ρ in Tables 4 and 5 suggests that the environmental performance of key environmental protection cities is moving into the same direction. Yet when we deploy an economic distance matrix in Table 6, ρ turns out to be negative and significant. For instance, when city j improves its total environmental transparency score by 1%, city i 's respective performance will drop by 3.7% (Table 6: ECON1). In the same vein, a 1% rise in the particulate matter reduction ratio in city j will reduce similar efforts in city i by 0.7 (Table 6: ECON2) and the sulphur dioxide ratio by 1.4% (Table 6: ECON3). The trend towards a widening environmental performance gap between municipalities with comparable income

levels stands in sharp contrast to signs of common regional and provincial standards. This observation corroborates previous theoretical work proposing that political centralization is the main institutional mechanism mitigating regulatory divergence as a result of economic decentralization in China (Blanchard and Shleifer 2000).

7 Conclusion

In this study, we show that model city programs raise the bar in terms of urban environmental governance. Our empirical analysis gives reason to suppose that environmental model cities are outstanding performers when we compare them to other key environmental protection cities in the same region or Province. What is more, there are significant spatial interaction effects that suggest that best practices spread to other municipalities. In this context, municipalities seem to learn from model cities with a comparable income level.

To the best of our knowledge, this study is the first attempt to measure the emulation effect of model cities. The study offers some policy-relevant insights: first, the analysis brings to the fore a rising gap between environmental performance among key environmental protection cities with a comparable economic development level. Second, we show that learning effects from model cities are strong among municipalities with similar income. Thus, even though we compare only a limited set of cities, we still believe it is fair to conclude that model city programs should differentiate between income groups and define for each of them specific objectives that emphasize regulatory cohesion and performance standards.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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