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Efficiency of Courts in China — Does Location Matter?

Xiaoge Dong

Abstract In this paper, we focus on determinants of judicial efficiency in China, with efficiency estimates of district courts obtained from data envelopment analysis (DEA). Our dataset comprises 1584 local courts pooled from the year 2014 - 2017. Controlling for local economic development level as well as the financial status and staff quality of local courts, we find a significant and robust impact of the location of local courts. More specifically, the performance of a court will be better when it is located in/closer to a higher city tier, the city center, the city government, or the provincial government even if the economic development of such areas is no better than others. Such courts probably receive (in)-direct political support and favorable local policy. Our result thus also has implications for judicial independence in China. Although the Chinese Central Government has been trying to separate the local legal system from local politics, local courts are still being affected by geopolitical factors in reality.

Keywords Chinese Court system · Court efficiency · data envelopment analysis · geopolitics

JEL Classification K1 · K40 · K30 · N45 · P21 · P37

1 Introduction

China is the most populous and one of the largest countries in the world. With its 1.4 billion citizens and 9.6 million km^2 territory, there have been everlasting discussions on how its political regime and infrastructure function in reality. In this paper, we focus on China's judicial system and investigate the influence of various geopolitical factors on its efficiency.

Judicial efficiency has been the focus of growing law and economic studies in recent years, particularly with the help of production frontier strategies such as data envelopment analysis (DEA) or stochastic frontier analysis (SFA). Admitting that measurement of judicial efficiency itself is an accomplishment, most studies do not offer an explanation of their outcome. In this paper, we employ data envelopment analysis to measure the efficiency of China's first instance courts and attempt to offer an explanation for its variation across different areas. Data envelopment analysis is a powerful tool to calculate the relative technical efficiency for weighted multiple-inputs and weighted multiple-outputs production units. It provides a method where production units with best practice will form an efficient production frontier, while those units which lie within the frontier are inefficient. For the judicial system, we often define the output as the number of cases finished, while the input often as the labor force. In this paper, we also incorporate the number of caseloads as input, yet we explain in Section 4 how we treat it as non-discretionary and is thus not under managerial control.

Inefficiency of production units is often interpreted as slacking or as inferior management. In spite of such interpretation, we exploit the impact of geopolitical factors among others on judicial efficiency. What we find out is that, first, economic development and financial situation contribute positively to judicial efficiency. A higher caseload also pressures court staff to work harder. Areas that are nominated by the Central Government to set lower criteria for candidates to join the national bar exam possibly attract judges with lower quality and thus are less efficient. Most importantly, geographic location plays a significant role in determining judicial efficiency. We consider 1) whether a court is located in different city tiers, 2) whether it is located in the city center rather than surrounding satellite cities, 3) whether its jurisdiction covers the local government office, 4) whether its jurisdiction covers the government office on a superior bureaucratic level. All four factors turn out to be significant, with signs as expected. Being located in a local political center induces higher court efficiency, and this effect persists after we control for the economic development level of different areas. We thus conclude that geopolitical factors are significantly associated with judicial efficiency, and such an association indicates possible *de facto* judicial dependence on the local political system.

Empirical studies on China have long been confronting the obstacle of data availability. Despite the huge potential which comes with the country's size, up till now there has been no central platform uniformly disclosing information on the local level. We thus have to collect all data manually and carefully rule out possible selection bias. The Central Government has been pushing forward the transparency of the judicial system through digitization while delegating this task to provinces/states. There are thus variations in the pace of local courts' digitization

work. We first have to exclude provinces/states where digitization had not yet started at the time we collected data. We then exclude provinces/states where digitization was in its initial stage and only the province center entered the pilot. There are, of course, provinces/states where digitization was in the making and we include them as long as there is no sign that only more developed cities are exhibited online. After data cleaning and pooling the year 2014 to 2017, we end up with 1584 observations. Compared to the total number of local courts, this is not a large number, but it is still larger than most existing studies. This makes our regression analysis more robust than other studies.

Our paper is the first to investigate the efficiency of the judicial system in such a large authoritarian country. We test the connection between court efficiency and geopolitical factors such as distance to the local political center. Our result thus also has implications for judicial independence in China. The remainder of the paper proceeds as follows. In Section 2 we offer a brief literature review of data envelopment analysis and its application to court systems. In Section 3 we offer the theoretical set-up of DEA analysis. In Section 4 we offer the description of our data and the data cleaning process. Section 5 offers the main empirical analysis and Section 6 offers a robustness analysis. Section 7 concludes.

2 Literature Review

Farrell (1957) in his seminal paper first proposes to combine the measurements of multiple inputs in order to construct a measure of efficiency. Building on this idea, Charnes et al. (1978) introduce data envelopment analysis (DEA), a non-parametric technology for the estimation of production frontier, or best-practice frontier in benchmarking. This technology has been later developed further by many scholars, bringing much variation to the original model (e.g., Caves et al. 1982; Banker et al. 1984; Deprins et al. 1984; Tulkens 1986; Banker and Morey 1986; Ruggiero 2004; Andersen and Petersen 1993; Chambers et al. 1998). Banker and Morey (1986) are the first to propose a formal model incorporating non-discretionary variables into DEA. Ruggiero (2004) improves this model by excluding potential production impossibilities.

Data envelopment analysis has been a technique widely applied to court efficiency. Most researches focus on the calculation and interpretation of efficiency estimates under DEA (See e.g., Lewin et al. 1982; Kittelsen and Førsund 1992; Pedraja-Chaparro and Salinas-Jimenez 1996; Dakolias 1999; Tulkens 2006; Cross and Donelson 2010, 2010; Elbially and García-Rubio 2011; Deyneli 2012; Santos and Amado 2014; Melcarne and Ramello 2015; Voigt 2016). In the meantime, there have also been concerns about whether environmental factors can also be incorporated into data envelopment analysis. Environmental factors are generally external variables not under managerial control but offer an operational environment, such as socioeconomic factors and governmental regulations. Coelli et al. (2005) propose several ways of tackling environmental factors, and one of them is to conduct the so-called two-stage DEA. In the first stage, traditional DEA is implemented, while in the second-stage, the efficiency estimates obtained from the first stage are regressed against different environmental factors. Such methodology has been widely adopted by scholars in recent years. Schneider (2005) investigates the performance of 9 German labor courts

of appeal after pooling the year 1980 to 1998. In the first stage, output variables include the number of closed cases and the number of published decisions. In the second-stage, the share of judges holding a Ph.D. degree, the share of elder judges, and the ex-ante promotion probability of judges are included as explanatory variables. It is concluded that the share of judges holding a Ph.D. degree significantly increases court efficiency, while a higher ex-ante promotion probability decreases it. Deyneli (2012) uses judge salaries, their education background, and the number of courts as explanatory variables in the second-stage. The author conducts a cross-country study and implements Tobit regression instead of OLS in order to control for the truncated value of efficiency estimates. Salary, in the end, contributes positively to judicial efficiency. Instead of simple DEA in the first stage, Castro and Guccio (2014) conduct a smoothed bootstrap procedure to generate the efficiency estimates considering their relatively small sample size. In the second-stage, different parametric and semi-parametric estimation approaches are implemented. Their second-stage result suggests that the technical efficiency of courts in Italy can be explained by demand factors. Besides, it is also affected by the opportunistic behavior of litigants and lawyers. Ippoliti et al. (2015) employ a dataset for European countries, which enables them to control for environmental variables such as judicial independence and legal origin. The authors also conduct an output-oriented bootstrap procedure. The authors study whether judicial efficiency, whether defined by clearance rate or technical efficiency, can explain the level of economic activity, and the assumption is largely confirmed. There are also other researches that combine Directional Distance Function (DDF) approach with second-stage regression analysis (Peyrache and Zago 2015; Falavigna et al. 2015).

Our paper targets the most populous authoritarian state in the world, with geopolitical factors being the focus in the second stage. Neither autocracy nor geopolitical factors has been thoroughly studied in former judicial efficiency researches. In addition, the sample size in our paper is much larger than most studies, which makes our result more robust.

3 Data Envelopment Analysis

DEA provides a methodology where production units with best practice will form an efficient production frontier, while those units which lie within the frontier are considered inefficient and the distance between such units and the frontier can be specified and calculated. The logic of DEA reflects the idea of *Pareto* optimality. A decision-making unit (DMU) is efficient if no other DMUs can produce a higher amount of outputs using the same amount of inputs (output-oriented), or producing the same amount of outputs using less amount of inputs (input-oriented).

Suppose we have n DMUs, with each j th ($j = 1, \dots, n$) DMU consumes m inputs x_{ij} ($i = 1, \dots, m$) and produces s outputs y_{rj} ($r = 1, \dots, s$). If we are able to know the price u_r and v_r for the outputs and inputs, or the multiplier associated with them, respectively, we can primarily express technical efficiency e_0 as the benefit/cost ratio:

$$\sum_r u_r y_{rj} / \sum_i v_i x_{ij} \quad (1)$$

When the value of the multiplier/price is unknown, which is often the case, Charnes et al. (1978) propose to derive the technical efficiency estimate for a certain DMU₀ by solving a non-linear programming issue, where the technical efficiency solves the following maximum problem:

$$\begin{aligned}
e_0 = \max \quad & \sum_r u_r y_{r0} / \sum_i v_i x_{i0} \\
\text{s.t.} \quad & \sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0, \quad \forall j \\
& u_r, v_i \geq \varepsilon, \quad \forall r, i
\end{aligned} \tag{2}$$

ε is to ensure the positivity of the values and was set to 0 at first (Charnes et al. 1978) and the minimum positive number later on (Charnes et al. 1981). The first constraint makes it clear that technical efficiency cannot be higher than unity. This set-up assumes constant returns to scale (CRS) and is input-oriented.¹ One could also transform the maximum problem into a linear programming model:

$$\begin{aligned}
\min \quad & \theta_0 - \varepsilon (\sum_r s_r^+ + \sum_i s_i^-) \\
\text{s.t.} \quad & \sum_j \lambda_j x_{ij} + s_i^- = \theta_0 x_{i0}, \quad \forall i \\
& \sum_j \lambda_j y_{rj} - s_r^+ = \theta_0 y_{r0}, \quad \forall r \\
& \lambda_j, s_r^+, s_i^- \geq 0, \quad \forall i, j, r \\
& \theta_0 \text{ unconstraint}
\end{aligned} \tag{3}$$

In equation 3, s_r^+ and s_i^- denote slacks. The model was later on extended to variable returns to scale (VRS) by Banker et al. (1984) through adding a convexity constraint:²

$$\begin{aligned}
e_0 = \max \quad & [\sum_r u_r y_{r0} - u_0] / \sum_i v_i x_{i0} \\
\text{s.t.} \quad & \sum_r u_r y_{rj} - u_0 - \sum_i v_i x_{ij} \leq 0 \quad \forall j \\
& u_r, v_i \geq \varepsilon \quad \forall r, i, \\
& u_0 \text{ unrestricted in sign}
\end{aligned} \tag{4}$$

Most literature prefers CRS to VRS unless there is a clear argument behind the variety of returns to scale among different peer DMUs. On one hand, it is not easy to derive the optimal size when there are multiple inputs and multiple outputs concerning different specializations and compositions of inputs (Bogetoft and Otto 2010).

1. An input - oriented efficient DMU with an efficient score of 1 cannot reduce its inputs while keeping the output level constant. An inefficient unit with a score of, e.g. 0.8, can reduce its inputs all by 20 percent while keeping its outputs constant. Instead, an output-oriented efficient unit cannot enlarge its output level while keeping the level of the input constant. An inefficient unit with a score of, e.g. 1.2, can enlarge its outputs all by 20 percent while keeping its inputs constant.

2. The difference between e_{CRS} and e_{VRS} (e_{CRS}/e_{VRS}) is often defined as scale efficiency (SE). If a DMU has different e_{CRS} and e_{VRS} , it is considered having scale inefficiency. Technical efficiency calculated under CRS can thus be decomposed into “pure” technical efficiency and scale efficiency.

On the other hand, it might not be realistic to think of rescaling a unit, particularly when it is for natural or administrative reasons such as the building of courts in China.³ Although on average, the estimates from CRS are lower than those from VRS, which might not be appealing for some managers of corresponding DMUs.

One important variation of the DEA model is the incorporation of non-discretionary inputs. For example, current literature either consider the number of court workload (pending cases from the previous year plus new cases from the current year) as ordinary input (e.g., Lewin et al. 1982) or ignore the case information and only consider labor and capital inputs (e.g., Elbially and García-Rubio 2011). It is reasonable to argue that court workload should be an input in order to get part (or all) of them finished and no case can be finished without having a filed case. On the other hand, it is also reasonable to argue that court workload is not something under court managerial control but rather the “working environment”, so it should not be included in the analysis. The efficiency of a certain court should be compared to its theoretical capacity, not how reality looks like. We will not try to draw a conclusion of which argument is theoretically superior, but rather attempt to reach a compromise between these two arguments. We include caseload as input but treat it differently, that is, we control for the fact that such inputs are not under managerial control and are thus not subject to possible improvement. Such modification challenges the Farrell approach because now inputs are not adjusted proportionally by the same factor. Another way would be to treat caseload simply as an environmental factor and incorporate it only in the second-stage, as is suggested by Coelli et al. (2005). This means that the dimensions of our inputs will be reduced and we will discuss this variation in Section 6.

Incorporation of non-discretionary inputs works as follows. Imagine we have a index set I_D with discretionary inputs, and a set I_F of non-discretionary inputs. We then have $I_D \cup I_F = I = \{1, \dots, M\}$ and $I_D \cap I_F = \emptyset$. Banker and Morey (1986) develop a model in the following form:

$$\begin{aligned}
 e_0 = \max \quad & [\sum_r u_r y_{r0} - \sum_{i \in I_F} v_i x_{i0} - u_0] / \sum_{i \in I_D} v_i x_{i0} \\
 \text{s.t.} \quad & \sum_r u_r y_{rj} - \sum_{i \in I_F} v_i x_{ij} - u_0 - \sum_{i \in I_D} v_i x_{i0} \leq 0 \quad \forall j \\
 & u_r, v_i \geq \varepsilon, \quad \forall r, i, \\
 & v_i \geq 0, \quad \text{for } i \in I_F \\
 & u_0 \text{ unrestricted in sign}
 \end{aligned} \tag{5}$$

In practice, a simple way to deal with non-discretionary inputs is to treat them as negative outputs in input-oriented model.⁴ One last point that worth noting is the fact that the number of cases closed cannot exceed the number of cases filed, in another word, there is an upper limit on the possible value of court output in reality. We will incorporate this constraint into our model with the help of controls under linear programming.

3. Peyrache and Zago (2015) is a paper where the authors explicitly deal with the size of courts when merging is possible.

4. A more technical way would be to introduce the concept of directional DEA, by which one can also manipulate the multiplier factor for input improvement individuals. Putting weight as 1 for all inputs indicates Farrell efficiency and input with weight 0 is treated as non-discretionary. When we assign 1 to the weight of discretionary inputs and 0 to the weight of non-discretionary inputs, it will offer the same result as when fixed inputs are treated as negative outputs.

4 Data

Due to China's large population and vast area, the administrative division of China comprises several levels. Correspondingly, the Chinese court system follows a pyramid-style⁵ - in the sense that there are many local courts, but only one supreme court. Courts on the lowest administrative level are the basic people's courts and each county/district in China has its basic people's court.

Our data analysis focuses on these Basic People's Courts. As of 2017, there were 2851 counties in China, indicating correspondingly 2851 basic courts. Data availability has always been an obstacle when trying to conduct empirical research in China. Fortunately, the transparency of the Chinese legal system has been improving in recent years, particularly as courts started to set up their own websites and publish relevant information online. In 2009, the supreme court published Six Provisions on Judicial Openness, aiming to improve the openness of non-confidential statistics. Recent legal reform also sets judicial transparency as one of its major goals.⁶ Local courts gradually publish statistics of their cases online and report their annual work to local people's congress at the end of the year. Some provinces, such as Zhejiang⁷ and Guangxi⁸, set up *ad hoc* platforms disclosing judicial statistics. Besides, some local people's congresses and local governments also started to publish relevant information online. In 2014, the biggest Internet company in China, Baidu, launched a joint project together with the supreme court, namely the Chinese Court map, which aims to offer basic information on all Chinese courts.⁹ In sum, there is no single platform that publishes all data for all courts, yet scattered information that can be aggregated is available.

Lacking a uniform data source indicates our data might be subject to potential selection bias. Those courts willing to offer information might be the ones performing better than their peers or at least the ones with better technologies. As of 2017, 6 provinces had not yet initiated the digitalization of its legal system, namely Xizang/Tibet, Neimenggu/Inner Mongolia, Hebei, Henan, Gansu, Liaoning. These provinces thus have to be dropped out from our analyses. On the other hand, Guizhou and Hainan were still in the initial phase of digitalization, offering a primarily constructed online framework and only a few inputs from their province center area. Although more observations is a treasure, we have to drop these provinces for the concern of biased results, thus excluding 800 counties out of 2581.¹⁰ Out of 31 provinces in mainland China, the Provinces excluded ranked 5th (Henan), 9th (Hebei), 14th (Liaoning), 21th (Inner Mongolia), 25th (Guizhou), 27th (Gansu), 28th (Hainan), 31th (Tibet) regarding GDP per capita as of 2017. Perhaps provinces dropped are more or less undeveloped compared to the rest. There is, on the other hand, no specific pattern of whether geographic location also has an effect. Indeed, Hebei and Henan are the nearest provinces to Peking.

5. Voigt (2012) compares a pyramid-style court system with a Greek temple style (consisting of a number of major columns).

6. See Judicial Reform of Chinese Courts, supreme court, 2016. Available at: http://english.court.gov.cn/2016-03/03/content_23724636_7.htm. Last visited 08 March 2020.

7. <http://www.zjsfgkw.cn/col/col420/index.html>. Last visited 08 March 2020.

8. <http://yggx.gxcourt.gov.cn/spry.jsp?wbtreeid=1147>. Last visited 08 March 2020.

9. <http://baike.baidu.com/court>. Last visited 08 March 2020.

10. 74 from Tibet, 103 from Inner Mongolia, 168 from Hebei, 158 from Henan, 86 from Gansu, 100 from Liaoning, 88 from Guizhou and 23 from Hainan. Source: Statistical Table of Administrative Divisions of the People's Republic of China, Ministry of Civil Affairs.

In sum, due to lack of data and concern of selection bias, we have to leave 8 provinces out. Our dataset thus contains 23 provinces. Furthermore, not all provinces are offering information on all aspects every year, we thus pool the year 2014 - 2017 for more observations following Schneider (2005). Our input variables for first stage DEA include the number of staff (*Staff*)¹¹ and the total workload (*TotalWorkload*). Our output is the number of cases finished (*CasesResolved*). Merging all available data for these three variables together, we end up with 1584 observations for 23 provinces. To briefly show whether such remaining selection procedure is again subject to severe selection bias, we draw maps for 3 variables individually¹² and the merged dataset. In Figure 4 to 6, blank areas are the 8 provinces excluded and grey areas are the counties without available data. For areas with available data, a darker color indicates more observations (up to 4). As the maps illustrate, information on the number of staff is quite abundant and on cases is less abundant but not highly biased. The mismatch of information on these variables results in much fewer observations, yet one cannot say there is obvious selection bias during the merging process.

For the second-stage analysis, we incorporate various geopolitical indicators. These include dummies on the tier of the corresponding city (*CityTier*), on whether the court is located in the city center (*City_center*), on whether the jurisdiction of the court covers the local government (*City_gov*), and the distance of a county to province center (*Distance_P*). City tier is a concept brought up to evaluate the attractiveness of each city according to the five aspects of commercial resource agglomeration, urban hubs, urban resident activity, lifestyle diversity, and future plasticity as the first-level dimensions. The value of this dummy ranges from 1 to 5, with 1 being the most developed and attractive, and vice versa. The city center is an administrative division concept. A “city”, in its narrow sense, consists only of certain districts in the city center, yet in a broader sense, it also includes its satellite cities in the surrounding, which are called counties in China. Well-developed counties can also turn into districts if they are adjacent to the city center. They can turn into county-level cities if they are far away from the city center. Districts, counties and county-level cities are all on the same administrative level and are each equipped with a court.¹³ Although for the first stage analysis, we do not distinguish among them; we include such a dummy in the second-stage taking into consideration that districts probably attract more political attention and receive favorable policies than counties and county-level cities. *City_gov* indicates whether the jurisdiction of a court covers local government, and we include this dummy for a similar reason as before. We have also included a general variable measuring the distance of a certain county to its province center. One substitute might be the distance to Peking. Yet considering China’s vast area and over 2000 counties, many political and economic policy decisions emanating from the central government are delegated to local governments. Some scholars argue that China qualifies as a quasi-federal system because it relies heavily on the delegation of tasks to various local subsidiaries functioning at subnational levels of government (Montinola et al. 1995; Zheng 2006; Ip 2012). We thus decide to use the distance to province center instead of to Peking.

11. Another aspect of labor input would be to consider judges instead of total staff. We replace staff with judges for robustness check and results are shown latter.

12. Available data source for total workload and cases resolved is the same, so we only create one map for these two.

13. To better illustrate the concept, one can refer to Figure 9 in the appendix. It shows the maps for two random Chinese cities, Chengdu and Suzhou, with blue areas being districts and grey areas being counties. The single pink area is the county which was upgraded to a district in 2016 resulting from its economic development and location.

It can be doubtful whether all four variables defined above simply capture the level of economic development of a certain area and possible financial condition of a certain local court. To control for this concern, we also include GDP per capita (*GDP_per_capita*) and court expenditure (*Expenditure*).

Another aspect is to look into the quality of judges by which educational background is often the indicator. We did not collect enough observations on the educational background of judges, so in this paper, we are going to use an indirect indicator for the quality of judges, namely a dummy variable showing whether the court is located in the area where the threshold of the educational background of candidates to register for the national bar exam is set to be lower (*looser_judge_restriction*).¹⁴ Although there is no guarantee that candidates from such areas will not be enrolled as court staff somewhere else, it is still plausible to assume that judges with lower educational backgrounds are more likely to end up in these areas after the screening process. We summarize all our variables after the detection of outliers.

Efficiency estimate under DEA is a relative measure and is thus highly sensitive to the existence of outliers. For example, a court performing abnormally different from other courts is likely to span the frontier and thus have an enormous influence on the evaluation of the remaining courts. This does not necessarily mean that such outliers come from errors, instead, some observations are rather suggested to be excluded from DEA analysis for precautionary reasons. At the end of the day, they could be the units where new technology first emerges or management practice first innovates (Bogetoft and Otto 2010, P. 147).

By drawing a scatterplot matrix with correlation for our inputs and outputs, we can have a glimpse of whether there are possible outliers. As is shown in Figure 10, there are a couple of dots located far away from the mass, indicating possible outliers. A more sophisticated and precise way would be to use the so-called data cloud method, which can specify multiple outliers under DEA at the same time (Wilson 1993, 2008). The general idea of this method is that the mass of all observations together is considered as a “cloud”, and the volume of such cloud (denoted as R) is proportional to the determinant of the combined matrix from the inputs and outputs. The volume will decrease if a unit is outside the remaining cloud but will not if it is in the middle of the cloud. That is to say, if removing certain unit significantly reduces the size of the remaining cloud, it must be placed away from the cloud and is an outlier. One can thus search for possible outliers by looking at the relative size of the remaining volume compared to the initial. The procedure of searching for an optimal number of outliers involves looking at the global minimum R (R_{min}) and the local minimum R calculated after deleting a certain number of units (R_r , where r denotes the number of units deleted). One has to look at minimum value because by saying “a certain number” of units, there are various combinations of units to constitute “a certain number” and one has to go through all combinations to specify the most likely outliers. The log ratio of R_{min}/R_r will differ from 0 if R_r is isolated from R_{min} , which in turn indicates the properness of deleting this number of firms.¹⁵ The line in Figure 1 connects the lowest points above 0 for different r s, and we will look for the last r where there is a clear gap between an individual point on the line and 0. We set the maximum number of possible outliers to be 12. This line peaks at 8 deleted courts, indicating

14. Source: National Bar Exam Center (2014). http://www.moj.gov.cn/organization/content/2014-06/09/ldgg_8281.html

15. For more explanation see e.g. Bogetoft and Otto (2010), P. 150

the existence of 8 outliers. Table 1 offers us the 8 outliers derived from our analysis. By looking into the dataset, the 8 outliers are 3 counties from Peking, 2 counties from Shanghai, and 3 counties from Guangdong.¹⁶ Figure 11 illustrates the 8 outliers on (x,y) scale with a very primary DEA production frontier plot. These 8 courts, located all in the most advanced areas in China, are obviously not all on/close to the efficiency frontier. This offers already a hint that economic development might not be the primary driving force behind court efficiency.

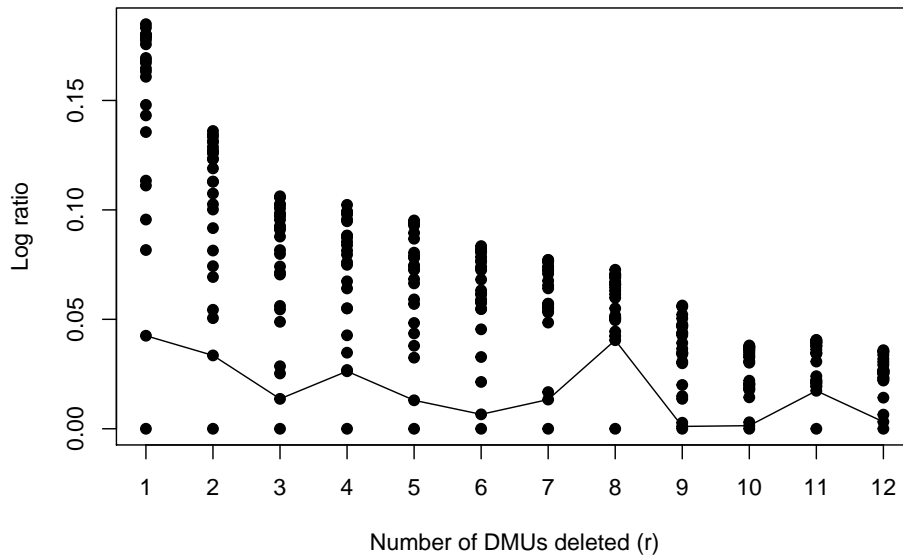


Fig. 1: Log - Ratio Plot

Table 1: r removed observations

r	Deleted Observations (i th)											R_r	
1	133											0.74	
2	4	133										0.61	
3	5	4	133									0.49	
4	132	5	4	133								0.40	
5	486	132	5	4	133							0.34	
6	486	1	132	5	4	133						0.31	
7	6	500	486	132	5	4	133					0.27	
8	6	500	486	1	132	5	4	133				0.24	
9	7	6	500	486	1	132	5	4	133			0.21	
10	496	7	6	500	486	1	132	5	4	133		0.19	
11	496	7	485	6	500	486	1	132	5	4	133	0.17	
12	501	496	7	485	6	500	486	1	132	5	4	133	0.16

8 courts are thus deleted from our dataset for a more robust result in the first stage, leaving us with 1576 observations. A summary of all variables is offered in Table 2. As the number of observations for court expenditure

16. The result stays the same no matter we consider non-discretionary inputs as negative output or not.

and GDP per capita is much lower than that from other variables, we also offer a summary table for variables excluding the missing values from these two. Results are shown in Table 4 and Table 5, respectively.

Table 2: Summary statistics

Variable	Description	Mean	Std. Dev.	Min.	Max.	Obs.
CasesResolved	Number of cases resolved every year	7283.323	8345.493	24	85587	1576
Staff	Number of staff	107.942	61.608	9	571	1576
TotalWorkload	Number of total workload every year	8407.960	9765.623	33	103597	1576
Lower_bar	Areas where admission criteria for bar exam is looser	0.257	0.437	0	1	1576
CityTier	Which tier of city is a court located	3.096	1.405	0	5	1576
City_center	Whether jurisdiction of a court is in the city center	0.914	0.921	0	2	1576
City_gov	Whether jurisdiction of a court covers city government	0.162	0.369	0	1	1576
log_Distance_P	Distance to province center(km)	5.171	1.02	0.68	8.166	1516
log_Expenditure	Annual total expenditure (10000 CNY)	7.847	0.697	5.472	10.345	1049
GDP_per_capita	GDP per capita (logged) (10000 CNY)	1.508	0.805	-0.592	4.382	877

5 Empirical Analysis

5.1 First stage

For the first stage of our analysis, we conduct traditional DEA estimation. As we have discussed in Section 3, there are two models treating non-discretionary inputs differently. While court staff is treated as standard input, the size of the caseload is often left out from the analysis as it is not (and should not be) under the control of local court (e.g., Kittelsen and Førsund 1992; Santos and Amado 2014). Yet a local court cannot solve any case with no incoming one. While some papers attempt to include it as ordinary input (e.g., Melcarne and Ramello 2015; Schneider 2005; Falavigna et al. 2015), we treat it specifically as a non-discretionary variable considering its dual property. What we also control for is the constraint that the number of cases closed cannot exceed the number of cases filed.¹⁷

Most literature on DEA within the court system assumes constant returns to scale (e.g., Schneider 2005; Lewin et al. 1982; Yeung and Azevedo 2009; Deyneli 2012). Once a case is filed, one always has to go through the standard legal procedure. If we ignore the variation in the complexity of cases, a certain amount of time and labor should always be devoted and this should not vary with the size of caseloads or labor force (Yeung and Azevedo 2009; Deyneli 2012). Considering the composition of the court, it is thus sensible to assume constant returns to scale. On the other hand, big cities with much larger staff size may gain specialized proficiency (Pedraja-Chaparro and Salinas-Jimenez 1996). *A priori* test result of economic scale for our dataset suggests production under constant returns to scale.¹⁸ In addition, the efficiency estimates obtained under the assumption of CRS have a correlation coefficient of 0.4725 with staff size and of 0.4081 with judge size, both of which are not high. We thus employ CRS

17. There is no court in reality leaving no pending cases at the end of the year, so the result is the same after controlling for this constraint.

18. For reference to the theoretical background of such a test, see Simar and Wilson (2002, 2011). For the practice of test see e.g., the manual from rDEA package in R.

assumption for our main analysis, yet we still include the result under VRS assumption in Section 6 for robustness check.

The efficiency estimates obtained while treating total workload as non-discretionary variable differs greatly from the ones obtained without such concern. One can have a brief look at this from Figure 12. Theoretically, the more the inputs are, the more difficult it is to find a peer unit or a combination of peer units that performs better in every dimension. It is thus reasonable that efficiency estimates obtained with 2 discretionary inputs are on average much higher. Oppositely, efficiency estimates with a non-discretionary input are on average lower with fewer inputs dimensions. Otherwise, courts can simply stay safe by not being compared to an observed peer which is similar in every input dimension but superior in output.

5.2 second-stage

Upon getting the estimates of technical efficiency, one might wonder whether other factors such as socioeconomic factors, educational background of court staff, age of court staff, court size, etc, influence court efficiency. There has been a trend in DEA literature to add a second-stage where such factors are taken into consideration. Landes et al. (1998) analyze the US courts and conclude that judges attending top law universities have better performance. Using data from US courts of appeals, Christensen and Szmer (2012) also find out that panels tried by judges with high expertise are faster. Schneider (2005) observes that judges with a Ph.D. degree are more productive than judges without. Ramseyer (2012) explores the performance of the Japanese court system and finds out that court productivity and adjudicatory speed correlate with intellectual ability, where intellectual ability is measured by whether the judge attended the most selective universities and passed the national bar exam faster. We follow this stream of thoughts and hypothesize that a higher/lower educational background of court staff (indicated by *Lower_bar* induces higher/lower efficiency.

What we also include in the second-stage are certain geopolitical indicators including *CityTier*, *City_center*, *City_gov* and a director measure of the distance to province center *Distance_P*. In order to control for the concern that such geopolitical indicators are only indirect measurements of local economic development and therefore the potential financial condition of a certain court, we also include *GDP_per_capita* and *Expenditure* representing local economic development and financial status of a court, respectively.

A primary attempt is to incorporate all potential environmental factors into an OLS regression using technical efficiency estimates we obtained from the first stage as the dependent variable. A linear model would take the form of :

$$e_0 = \alpha_1 1 + \alpha_2 x_2 + \dots + \alpha_q x_q + \varepsilon = \alpha x + \varepsilon \quad (6)$$

where ε is the error term. Although coefficients OLS are easy to interpret, this method does not take into account that efficiency score is censored between 0 and 1 and that plenty estimates are indeed at the boundary of

1. Solution to this problem would be to use Tobit model in the following form:

$$e_0 = \begin{cases} 0, & \text{if } \alpha x + \varepsilon \leq 0 \\ \alpha x + \varepsilon, & \text{if } 0 < \alpha x + \varepsilon < 1 \\ 1, & \text{if } \alpha x + \varepsilon \geq 1 \end{cases} \quad (7)$$

Table 3 illustrate our estimation results with estimation technology written on top. The first two columns do not include *GDP_per_capita* or *Expenditure* and the latter four include them individually. We cluster our observations on the province level by including dummies for each province. As the table shows, the economic development level and financial status of a court do improve court efficiency significantly. Including them reduced the effects from other variables but do not eliminate their effects except for one, regardless of the model set-ups. Lower admission criteria for bar exam results in lower staff quality and court efficiency. Courts located in lower city tiers or further away from the province center have lower efficiency. On the other hand, courts located in the city center or next to the city government have higher efficiency.

To explain the results more explicitly, it is intuitive that a higher salary or better working conditions incentivize court staff to work harder, particularly as there is an incentive payment scheme in the legal system. However, even after controlling for economic/financial concerns, other variables are still highly significant. An equally developed/financed area will attract less qualified candidates because it set lower criteria for the bar exam. Most importantly, an equally developed/financed area gets less political attention and favorable policy simply because its location is far from the local and provincial political center. A county-level city may well be more developed than a district, yet it cannot receive comparable political benefits because of its location. Such favoritism towards political centered area casts doubt on what the local government receives in return. The *de-facto* independence of local courts is therefore also under question. Although on the other hand, the document from the central government makes it crystal clear that “*Judicial power belongs to the Central Government...*”¹⁹ One thus should not be surprised if (in)direct political support is an important factor behind judicial efficiency. Another explanation of such a result could be that courts located closer to the political center confront higher pressure on their performance and are thus driven to perform better. Yet we did not find evidence that judicial performance enters the performance assessment system of local government, and even if so, central-located courts should not receive higher weights during the assessment.²⁰

19. See Judicial Reform of Chinese Courts, supreme court. Available at http://english.court.gov.cn/2016-03/03/content_23724636_4.htm

20. Although we clarified the reason for including the distance to province center instead of Peking, we still check for the significance of distance to Peking. It turns out to be insignificant but does not affect the result from other variables much. Although Peking is the absolute political center, but with China’ 9.6 million km² territory and 3674.7 km distance from Kashi, Xinjiang to Peking, it is difficult to believe that variation in political impact can be detected that far.

Table 3: Second-stage panel regression result (CRS)

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.022** (0.008)	-0.024** (0.008)	-0.022* (0.009)	-0.026** (0.009)	-0.018 (0.009)	-0.024** (0.009)
CityTier ²	-0.031*** (0.003)	-0.032*** (0.003)	-0.016*** (0.003)	-0.024*** (0.003)	-0.019*** (0.003)	-0.023*** (0.003)
City_center ³						
County-level city	0.013 (0.008)	0.013 (0.008)	0.002 (0.009)	0.006 (0.009)	0.006 (0.009)	0.009 (0.009)
District	0.032*** (0.008)	0.028*** (0.007)	0.029*** (0.008)	0.028*** (0.008)	0.010 (0.009)	0.018* (0.008)
City_gov	0.053*** (0.009)	0.055*** (0.008)	0.034*** (0.010)	0.044*** (0.009)	0.039*** (0.011)	0.040*** (0.010)
log_Distance_P	-0.020*** (0.004)	-0.019*** (0.004)	-0.011* (0.005)	-0.014** (0.004)	-0.010* (0.005)	-0.010* (0.005)
log_Expenditure			0.081*** (0.007)	0.045*** (0.005)		
GDP_per_capita					0.028*** (0.006)	0.013** (0.005)
Other controls ⁴						
sigma_u		0.064*** (0.002)		0.061*** (0.002)		0.057*** (0.002)
sigma_e		0.036*** (0.001)		0.031*** (0.001)		0.030*** (0.001)
N	1515	1515	1011	1011	869	869
R ²	0.618		0.675		0.654	
adj. R ²	0.604		0.659		0.637	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

¹ Dependent variable is efficiency estimate obtained from DEA with CRS assumption, using staff size and total workload as inputs.

² We also run the regression considering *CityTier* as category variable. Results are consistent.

³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city Center consists only of districts.

⁴ Other controls include year dummy and dummies for each province.

6 Robustness analysis

6.1 Smoothed bootstrapping/VRS assumption of the first stage

As we have mentioned before, the estimation of efficiency under DEA is a relative efficiency measure and can be highly sensitive to the selection of the reference set. We excluded possible outliers before implementing empirical analysis, yet for further sensitivity analysis, we are going to conduct a smoothed bootstrapping procedure to control for derived bias and skewness from the DEA estimation. We re-sample our data with 2000 replications and the resulting distribution of efficiency estimates before and after bootstrapping is shown in Figure 13. Bootstrapping procedure gives a slightly lower efficiency estimate on average.

For the second-stage analysis, we include the same set of explanatory variables and the regression result is illustrated in Table 6 in the Appendix. Overall, our regression result stays highly consistent with the one obtained from our main analysis. The only change comes from variable *City_center* and *log_Distance_P* using Tobit regression. Now the positive effect of *City_center* is significant in the last model set-up, while the negative effect of *log_Distance_P* is insignificant.

The next modification would be to assume variable returns to scale instead of constant returns to scale. The distribution of efficiency estimates with VRS assumption is also shown in Figure 13. Estimates now are on average higher than before, because allowing for varying returns to scale increases the number of units on the efficient frontier and different units become more comparable.²¹

Second-stage estimation offers a quite different result. While court expenditure and local economic development are still significantly important for court efficiency, other variables to some extent lose their significance as these two are controlled for. When neither is included, geopolitical factors are still highly important, which also holds true when court expenditure is controlled for. However, when we control for local economic development, distance to the provincial center is not significant anymore, and the effect of other variables is also eliminated when we employ OLS regression.

6.2 Judges as input instead of staff

The number of judges and the number of staff are two common ways to measure the labor input of a court, and the choice between them largely depends on the availability of data. In this section we are going to use judge instead of staff as labor input, although the number of observations drops to 1244 and the explanation power is thus weakened.

We repeat the outlier detection procedure and exclude 4 outliers according to Figure 2. We then run the data envelopment analysis and regression analysis. Results are shown in Table 8 -10.

Our explanatory variables still turn out to be mostly significant under the assumption of constant returns to scale although the size of the effect shrinks. The same holds for efficiency estimated obtained through bootstrapped procedure. However, most variables turn insignificant when efficiency estimates are obtained under VRS assumption, and the only factor robust to different model set-ups is whether a court is located in the city center or not. *Ceteris paribus*, being located in the city center, even equally financed as other courts, increases court efficiency by 2 percent on average.

21. One can refer to Figure 14 to see the difference between two assumptions.

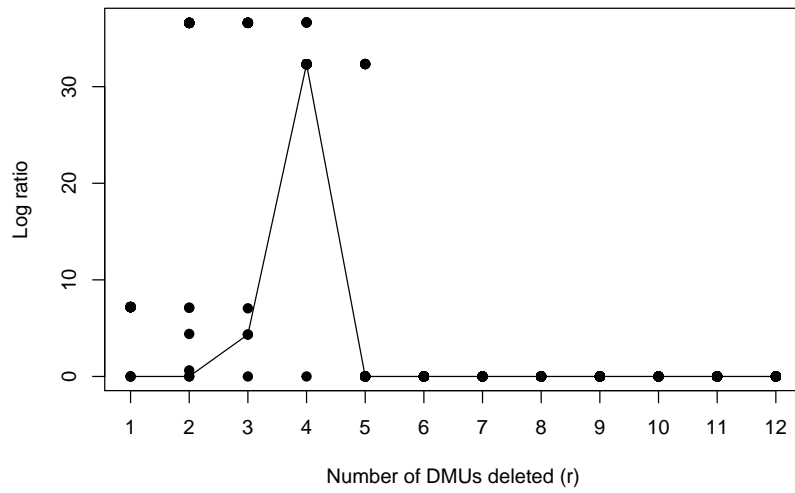


Fig. 2: Log - Ratio Plot (1)

6.3 non-discretionary variables as environmental factors

As is discussed in Coelli et al. (2005), one solution to deal with non-discretionary inputs is to treat them as environmental factors and include them only in the second-stage. In this section, we are going to move *TotalWorkload* directly into the second-stage. Our input variables will then be *Staff* and our output variable will be *CasesResolved*. Again, we go through the outlier detection procedure. Figure 3 does not indeed signal absolute outlier, but we decide to exclude two observations for safety concern.

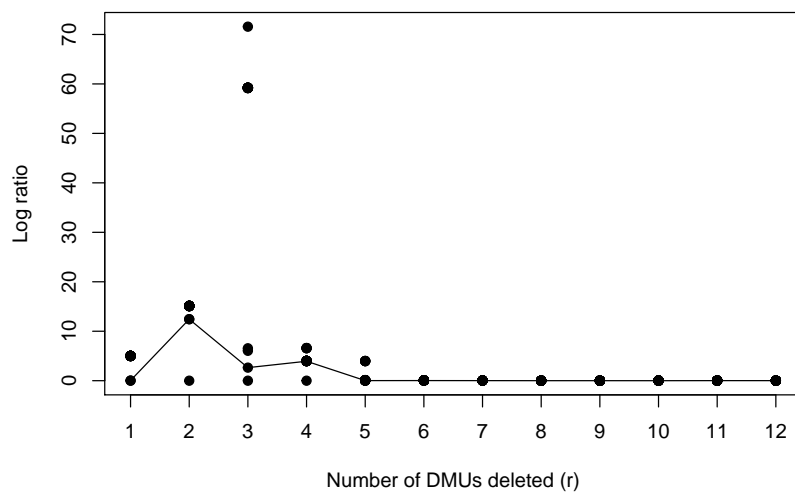


Fig. 3: Log - Ratio Plot (2)

For the second-stage regression analysis, we have an additional explanatory variable, namely the caseload. We divided it by 1000 for rescaling. Regression results are shown in Table 11 to Table 13. As is shown from the tables, the caseload is an important determinant of court efficiency, although the effect itself is minimal. Even the largest court with 100 thousand cases coming annually is not that distinguishable from an average one concerning efficiency. On top of this new explanatory variable, the rest show quite a similar pattern as that from the main analysis. Still, the most robust result comes from whether the court is located in the city center. It offers local court 2 percent extra efficiency on average irrespective of the assumptions behind it. Most variables are significant at least before we controlled for local economic development.

In sum, analysis from this section shows results derived from our main analysis are quite robust. Although efficiency estimates obtained from the first stage vary among different set-ups in the first stage, second-stage regression results are to a large extent consistent across different models. Being located in the city center brings the most robust result. Court expenditure as well as local economic development also proves to be beneficial to court efficiency. Lower admission bar for bar exam fails to be significant mostly when VRS is assumed in the first stage. And other geopolitical factors become insignificant in certain regressions.

7 Conclusion

In this paper, we investigate whether such efficiency can be explained by educational factors and geopolitical factors. We consider the number of cases closed as court output. Court staff size is considered as discretionary court input and the number of filed cases is considered as non-discretionary court inputs not under managerial control. We conduct data envelopment analysis to get court efficiency estimates and run OLS/Tobit regression employing these efficiency estimates as the dependent variable in the second-stage.

Our regression result suggests that first of all, higher local economic development level and higher court financial support positively contributes to court efficiency. Court staff will probably be more incentivized when their financial status can be guaranteed. Secondly, areas with a lower admission bar for the national bar exam result in lower quality of court staff and negatively affects court efficiency. Most importantly, geopolitical factors can also explain court efficiency, and such impact still exists after controlling for the concern that politically more centered areas might simply be more developed. Courts located in higher city tier, in the city center, next to city government or closer to province center are having higher efficiency. For two equally developed areas, one will have higher court efficiency thanks to its location. One may argue that such an effect comes from political pressure from superiors, but there is no evidence that courts are treated differently when city government leaders are being evaluated. A more convincing reasoning would be that politically more centered areas are more likely to draw better political attention and receive favorable policies. This brings up the question of what the local political center receives in return. One thus might doubt the independence of local courts in China, although absolute independence is never the target of the Chinese central government.

Studies on China generally confront the challenge of data availability. Our dataset is not perfect but to a large extent unbiased and large. This is the first study on determinants of court efficiency from an authoritarian regime where uniformity of local court system is often desired. Our dataset comprises over 1500 observations, much larger than other studies on court efficiency. As judicial transparency is gaining more attention now in China, future studies can extend the dataset to an unbalanced panel and the quality of cases resolved may also be available in the future.

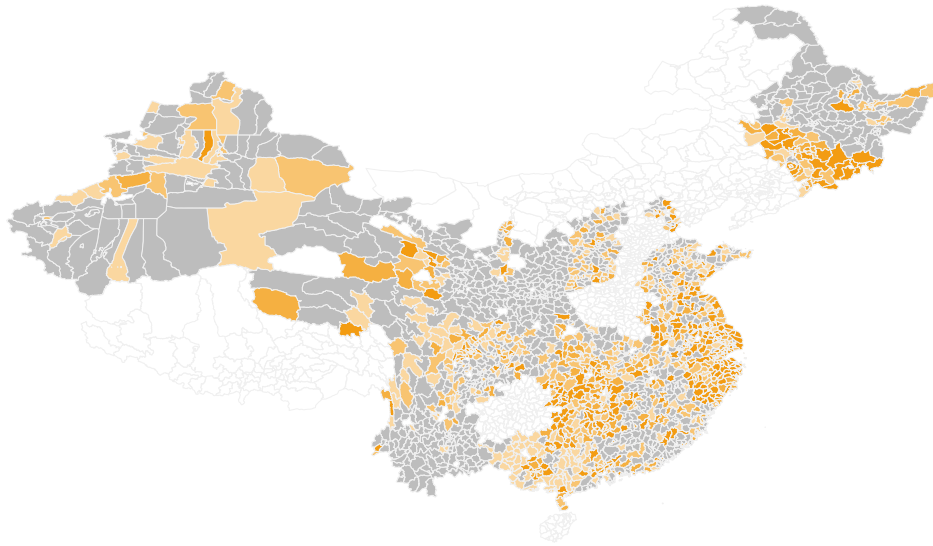
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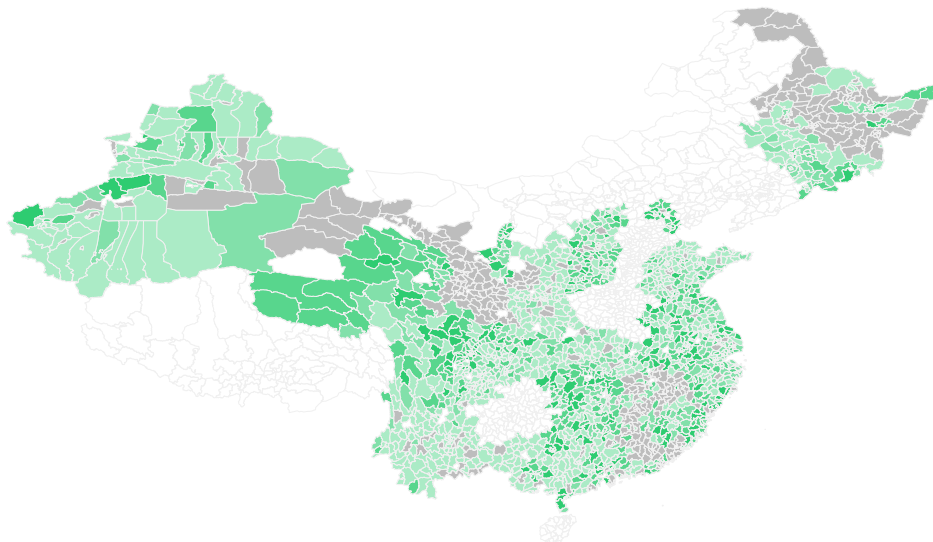
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Appendix



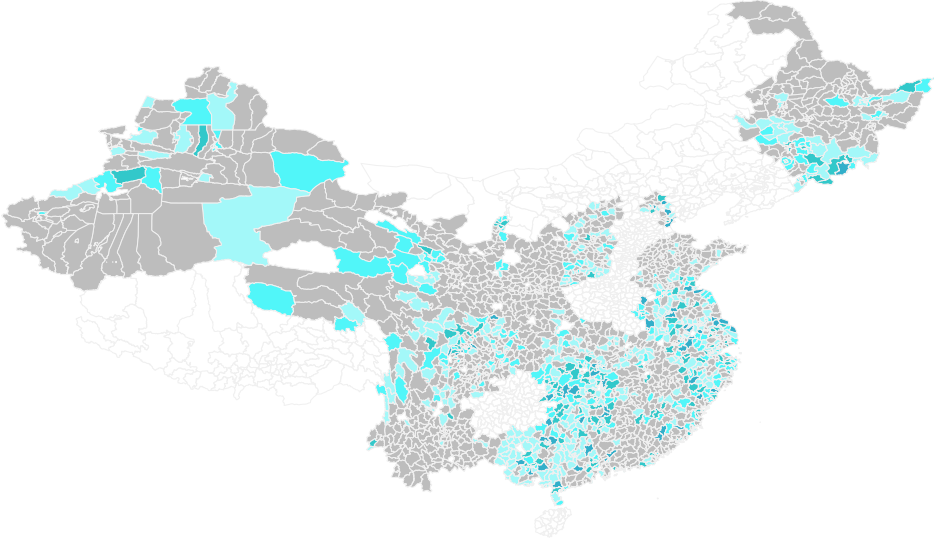
Areas excluded during data collection are in color, while areas without available data are in grey.
 Data on 41 courts are not included because this version of map does not capture their corresponding locations.
 9 courts from Jilin and Xinjiang, the north-east province and the north-west province, share the same location with another court.
 The rest belong to newly developed administrative units whose locations haven't been updated.
 Source of Map: The Ministry of Civil Affairs. Draft approval No. GS(2016)2512
 This map only includes areas in mainland China.

Fig. 4: Units with data on number of cases resolved



Areas excluded during data collection are in color, while areas without available data are in grey.
 Data on 94 courts are not included because this version of map does not capture their corresponding locations.
 34 courts from Jilin and Xinjiang, the north-east province and the north-west province, share the same location with another court.
 The rest belong to newly developed administrative units whose locations haven't been updated.
 Source of Map: The Ministry of Civil Affairs. Draft approval No. GS(2016)2512
 This map only includes areas in mainland China.

Fig. 5: Units with data on number of staff



*Areas excluded during data collection are in color, while areas without available data are in grey.
Data on 28 courts are not included because this version of map does not capture their corresponding locations.
10 courts from Jilin and Xinjiang, the north-east province and the north-west province, share the same location with another court.
The rest belong to newly developed administrative units whose locations haven't been updated.
Source of Map: The Ministry of Civil Affairs, Draft approval No. GS(2018)2512
This map only includes areas in mainland China.*

Fig. 6: Units with data on all variables

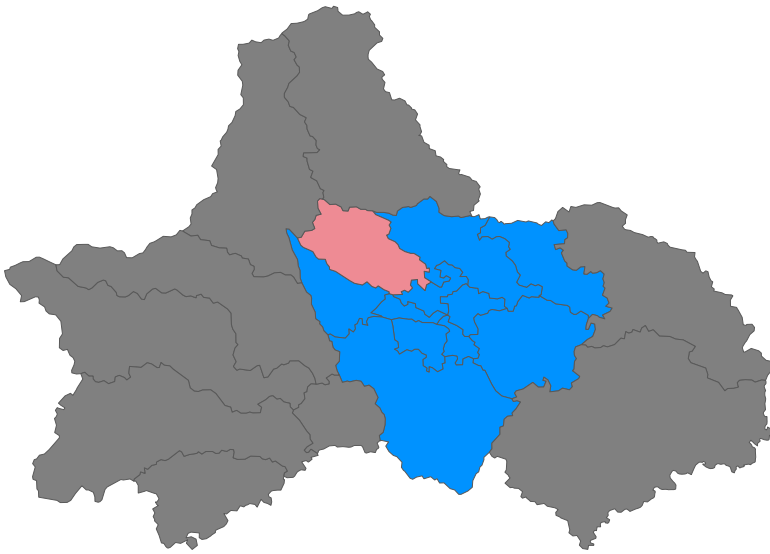


Fig. 7: Map for Chengdu, Sichuan

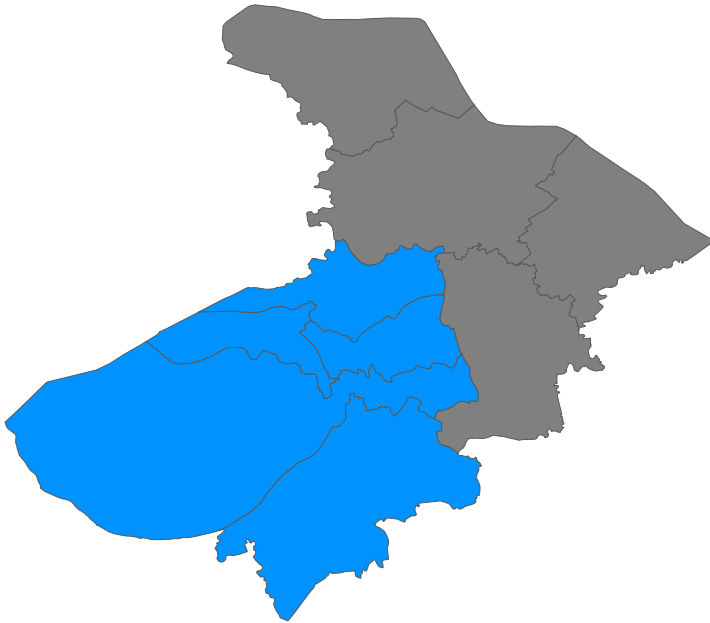


Fig. 8: Map for Suzhou, Jiangsu

Fig. 9: Maps for Chengdu and Suzhou

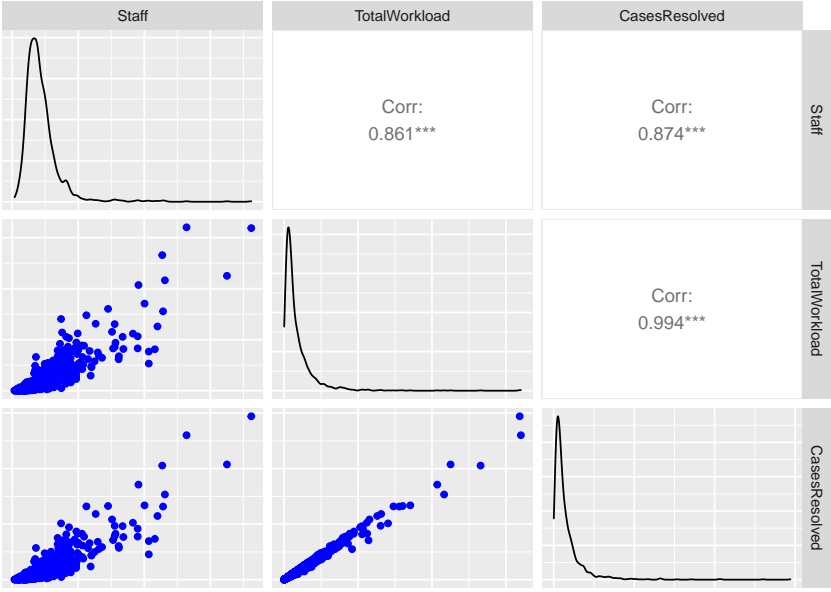


Fig. 10: Scatterplot matrix for 2 inputs and 1 output

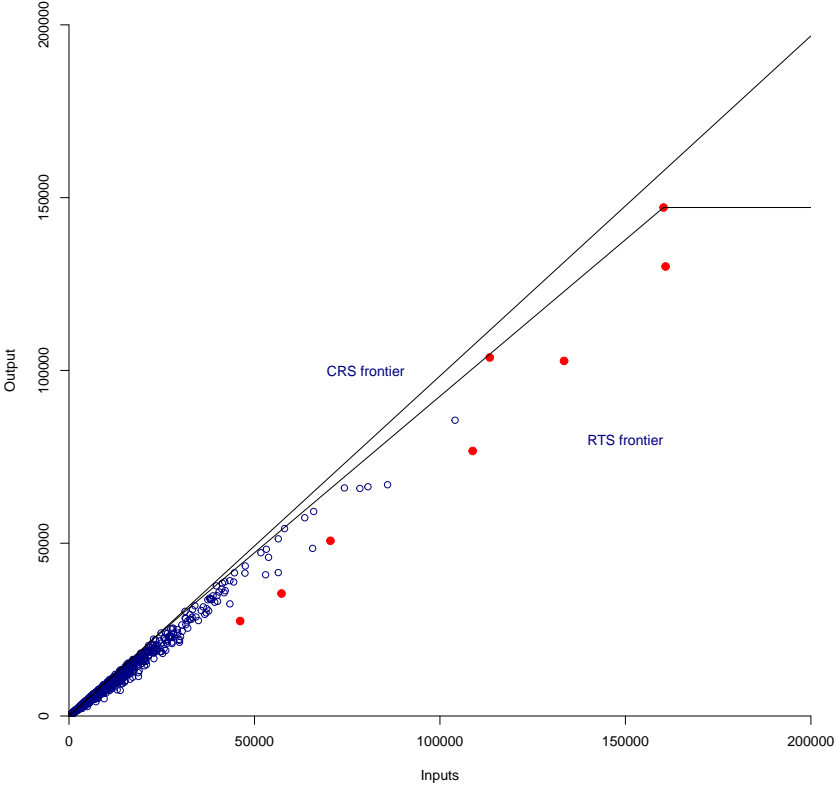


Fig. 11: DEA frontier (aggregated input)

Table 4: Summary statistics (1)

Variable	Description	Mean	Std. Dev.	Min.	Max.	Obs.
CasesResolved	Number of cases resolved every year	7209.351	7478.709	338	66917	877
Staff	Number of staff	112.552	58.455	33	571	877
TotalWorkload	Number of total workload every year	8338.087	8785.148	375	85380	877
Lower_bar	Areas where admission criteria for bar exam is looser	0.225	0.418	0	1	877
CityTier	Which tier of city is a court located	2.941	1.299	0	5	877
City_center	Whether jurisdiction of a court is in the city center	0.86	0.903	0	2	877
City_gov	Whether jurisdiction of a court covers city government	0.138	0.345	0	1	877
log_Distance_P	Distance to province center(km)	5.102	0.917	0.682	6.99	870

Table 5: Summary statistics (2)

Variable	Description	Mean	Std. Dev.	Min.	Max.	Obs.
CasesResolved	Number of cases resolved every year	7563.651	8665.298	24	85587	1049
Staff	Number of staff	109.143	63.77	9	550	1049
TotalWorkload	Number of total workload every year	8748.516	10126.86	33	103597	1049
Lower_bar	Areas where admission criteria for bar exam is looser	0.276	0.447	0	1	1049
CityTier	Which tier of city is a court located	3.097	1.437	0	5	1049
City_center	Whether jurisdiction of a court is in the city center	0.905	0.921	0	2	1049
City_gov	Whether jurisdiction of a court covers city government	0.168	0.374	0	1	1049
log_Distance_P	Distance to province center(km)	5.17	1.035	0.682	8.166	1011

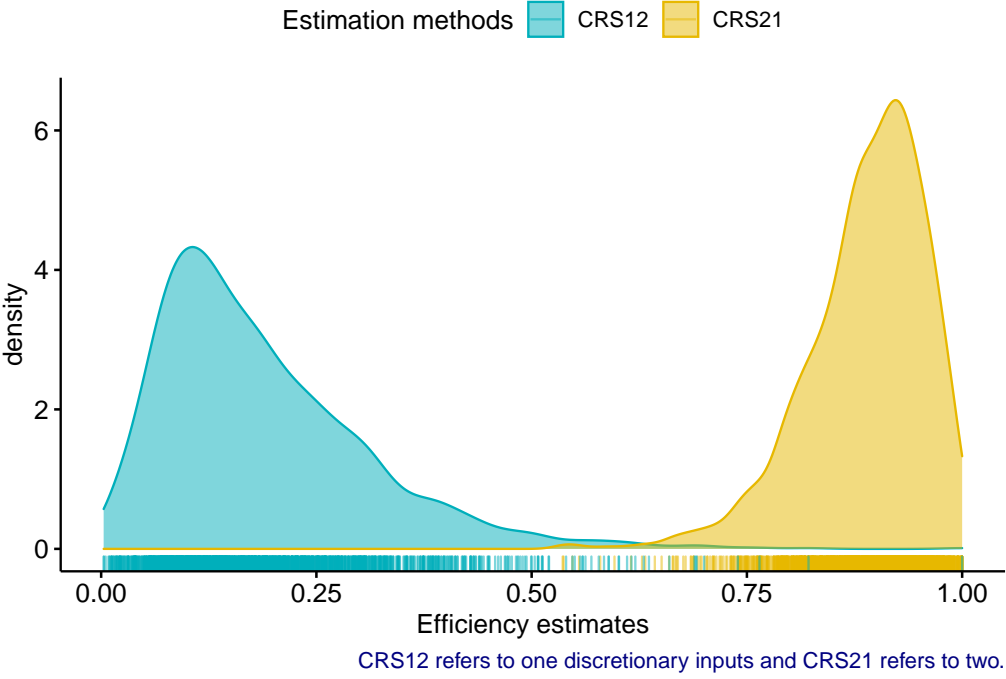


Fig. 12: Density plot for efficiency estimates

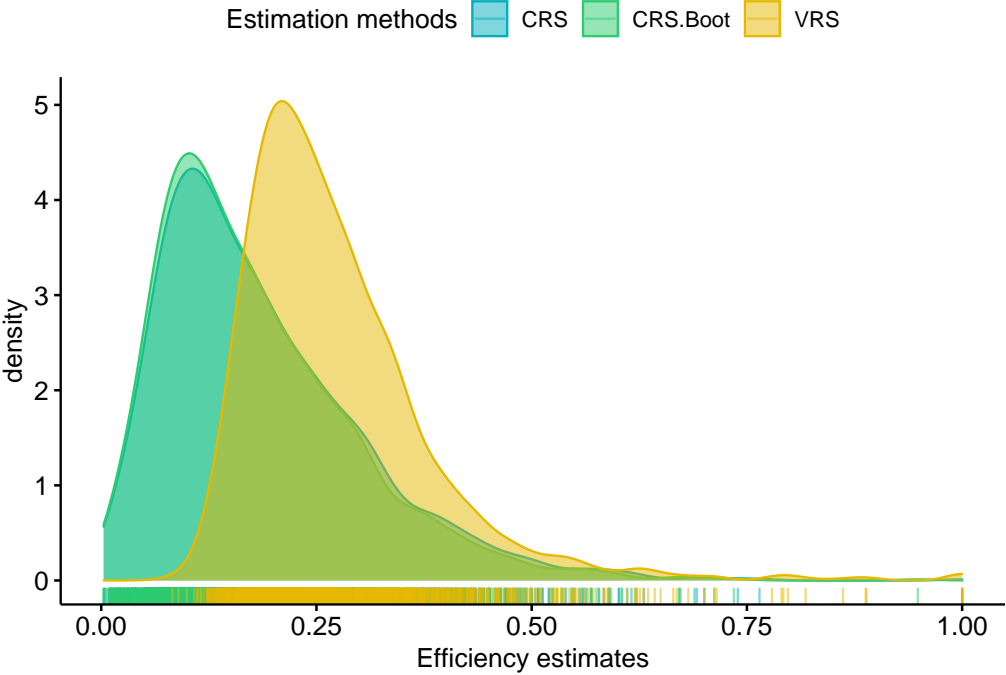


Fig. 13: Density plot for efficiency estimates (1)

Table 6: Second-stage panel regression result (CRS, Bootstrapped)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.021** (0.008)	-0.023** (0.008)	-0.021* (0.009)	-0.026** (0.008)	-0.017 (0.009)	-0.017* (0.008)
CityTier ²	-0.030*** (0.003)	-0.031*** (0.002)	-0.016*** (0.003)	-0.023*** (0.003)	-0.019*** (0.003)	-0.011*** (0.003)
City_center ³						
County-level city	0.012 (0.008)	0.012 (0.008)	0.001 (0.009)	0.006 (0.009)	0.006 (0.009)	-0.000 (0.008)
District	0.031*** (0.007)	0.027*** (0.007)	0.028*** (0.008)	0.027*** (0.008)	0.010 (0.009)	0.021** (0.008)
City_gov	0.051*** (0.008)	0.053*** (0.008)	0.033*** (0.009)	0.042*** (0.009)	0.038*** (0.010)	0.018 (0.010)
log_Distance_P	-0.020*** (0.004)	-0.018*** (0.004)	-0.010* (0.004)	-0.013** (0.004)	-0.010* (0.005)	-0.005 (0.004)
log_Expenditure			0.078*** (0.007)	0.043*** (0.005)		
GDP_per_capita					0.026*** (0.006)	0.024*** (0.005)
Other controls ⁴						
sigma_u		0.061*** (0.002)		0.059*** (0.002)		0.050*** (0.002)
sigma_e		0.034*** (0.001)		0.030*** (0.001)		0.032*** (0.001)
N	1515	1515	1011	1011	869	869
R ²	0.617		0.674		0.653	
adj. R ²	0.604		0.658		0.636	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

¹ Dependent variable is efficiency estimate obtained from DEA with CRS assumption, using staff size and total workload as inputs.

² We also run the regression considering *CityTier* as category variable. Results are consistent.

³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.

⁴ Other controls include year dummy and dummies for each province.

Table 7: Second-stage panel regression result (VRS)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.008 (0.009)	-0.010 (0.009)	-0.014 (0.010)	-0.015 (0.010)	-0.011 (0.009)	-0.017* (0.008)
CityTier ²	-0.016*** (0.003)	-0.018*** (0.003)	-0.014*** (0.004)	-0.016*** (0.003)	-0.008* (0.003)	-0.011*** (0.003)
City_center ³						
County-level city	-0.001 (0.009)	0.000 (0.009)	-0.003 (0.010)	0.002 (0.010)	-0.003 (0.008)	-0.000 (0.008)
District	0.041*** (0.008)	0.035*** (0.008)	0.039*** (0.009)	0.036*** (0.009)	0.014 (0.009)	0.021** (0.008)
City_gov	0.024* (0.010)	0.028** (0.009)	0.020 (0.011)	0.024* (0.010)	0.015 (0.010)	0.018 (0.010)
log_Distance_P	-0.023*** (0.005)	-0.022*** (0.004)	-0.015** (0.005)	-0.015** (0.005)	-0.005 (0.004)	-0.005 (0.004)
log_Expenditure			0.024** (0.008)	0.017** (0.006)		
GDP_per_capita					0.037*** (0.005)	0.024*** (0.005)
Other controls ⁴						
sigma_u		0.069*** (0.002)		0.067*** (0.002)		0.050*** (0.002)
sigma_e		0.039*** (0.001)		0.034*** (0.001)		0.032*** (0.001)
N	1515	1515	1011	1011	869	869
R ²	0.437		0.471		0.583	
adj. R ²	0.417		0.445		0.563	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ ¹ Dependent variable is efficiency estimate obtained from DEA with VRS assumption, using staff size and total workload as inputs.² We also run the regression considering *CityTier* as category variable. Results are consistent.³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.⁴ Other controls include year dummy and dummies for each province.

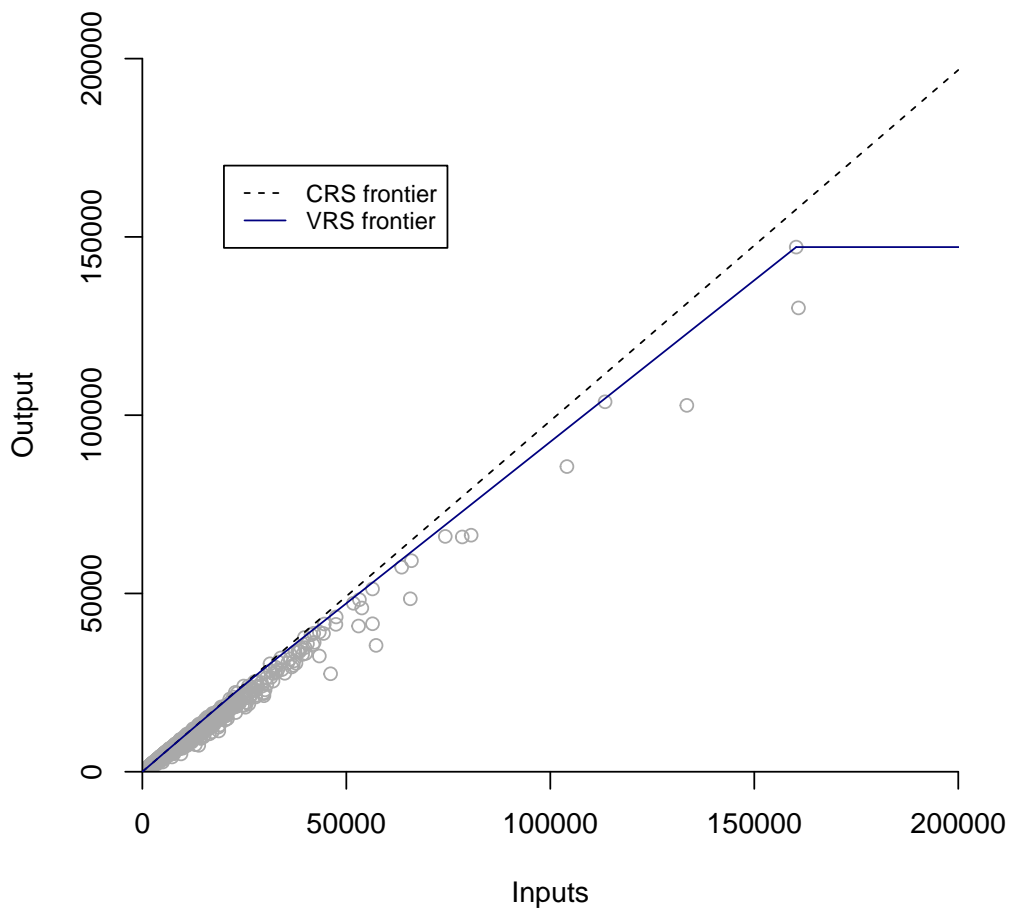


Fig. 14: DEA frontier (1)

Table 8: Second-stage panel regression result (CRS_1)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.014*	-0.015*	-0.015	-0.018*	-0.008	-0.013
	(0.007)	(0.007)	(0.009)	(0.008)	(0.008)	(0.008)
CityTier ²	-0.020***	-0.021***	-0.007*	-0.009***	-0.008*	-0.009**
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
City_center ³						
County-level city	0.005	0.003	0.005	0.004	0.013	0.012
	(0.007)	(0.007)	(0.009)	(0.009)	(0.008)	(0.008)
District	0.016*	0.016*	0.024**	0.020**	0.016	0.020*
	(0.006)	(0.006)	(0.008)	(0.008)	(0.009)	(0.008)
City_gov	0.035***	0.035***	0.019*	0.021*	0.010	0.017
	(0.007)	(0.007)	(0.009)	(0.009)	(0.010)	(0.010)
log_Distance_P	-0.008*	-0.007*	-0.005	-0.006	-0.012**	-0.011**
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
log_Expenditure			0.052***	0.044***		
			(0.007)	(0.006)		
GDP_per_capita					0.010*	0.001
					(0.005)	(0.004)
Other controls ⁴						
sigma_u		0.043***		0.044***		0.031***
		(0.002)		(0.003)		(0.003)
sigma_e		0.043***		0.036***		0.041***
		(0.001)		(0.002)		(0.002)
N	1170	1170	668	668	548	548
R ²	0.580		0.618		0.681	
adj. R ²	0.563		0.593		0.661	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ ¹ Dependent variable is efficiency estimate obtained from DEA with CRS assumption, using judge size and total workload as inputs.² We also run the regression considering *CityTier* as category variable. Results are consistent.³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.⁴ Other controls include year dummy and dummies for each province.

Table 9: Second-stage panel regression result (CRS_1, Bootstrapped)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.013* (0.006)	-0.013* (0.006)	-0.013 (0.009)	-0.016* (0.008)	-0.007 (0.008)	-0.015 (0.008)
CityTier ¹	-0.019*** (0.002)	-0.020*** (0.002)	-0.007* (0.003)	-0.009*** (0.003)	-0.007* (0.003)	-0.001 (0.003)
City_center ¹						
County-level city	0.005 (0.007)	0.003 (0.007)	0.005 (0.009)	0.004 (0.008)	0.013 (0.008)	0.006 (0.008)
District	0.016** (0.006)	0.015* (0.006)	0.023** (0.008)	0.020** (0.007)	0.016 (0.008)	0.020* (0.008)
City_gov	0.033*** (0.007)	0.034*** (0.007)	0.018* (0.009)	0.020* (0.008)	0.010 (0.009)	0.010 (0.010)
log_Distance_P	-0.007* (0.003)	-0.007* (0.003)	-0.005 (0.004)	-0.006 (0.004)	-0.012** (0.004)	-0.006 (0.004)
log_Expenditure			0.049*** (0.006)	0.041*** (0.005)		
GDP_per_capita					0.009* (0.005)	0.004 (0.004)
Other controls ¹						
sigma_u		0.041*** (0.002)		0.042*** (0.003)		0.028*** (0.004)
sigma_e		0.040*** (0.001)		0.034*** (0.002)		0.046*** (0.003)
N	1170	1170	668	668	548	548
R ²	0.581		0.618		0.680	
adj. R ²	0.564		0.593		0.660	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

¹ Dependent variable is efficiency estimate obtained from DEA with CRS assumption, using judge size and total workload as inputs.

² We also run the regression considering *CityTier* as category variable. Results are consistent.

³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.

⁴ Other controls include year dummy and dummies for each province.

Table 10: Second-stage panel regression result (VRS_1)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.010 (0.009)	-0.010 (0.009)	-0.012 (0.012)	-0.013 (0.012)	-0.010 (0.009)	-0.015 (0.008)
CityTier ²	-0.004 (0.003)	-0.005 (0.003)	0.000 (0.004)	0.000 (0.004)	0.000 (0.003)	-0.001 (0.003)
City_center ³						
County-level city	-0.008 (0.009)	-0.010 (0.009)	0.001 (0.012)	-0.001 (0.012)	0.007 (0.009)	0.006 (0.008)
District	0.020* (0.008)	0.018* (0.008)	0.025* (0.011)	0.021 (0.011)	0.016 (0.009)	0.020* (0.008)
City_gov	0.011 (0.010)	0.013 (0.009)	0.011 (0.013)	0.011 (0.012)	0.001 (0.010)	0.010 (0.010)
log_Distance_P	-0.011* (0.005)	-0.011* (0.004)	-0.010 (0.006)	-0.010 (0.006)	-0.007 (0.004)	-0.006 (0.004)
log_Expenditure			0.018 (0.009)	0.019* (0.008)		
GDP_per_capita					0.014** (0.005)	0.004 (0.004)
Other controls ⁴						
sigma_u		0.055*** (0.003)		0.059*** (0.004)		0.028*** (0.004)
sigma_e		0.053*** (0.002)		0.053*** (0.003)		0.046*** (0.003)
N	1170	1170	668	668	548	548
R ²	0.414		0.419		0.643	
adj. R ²	0.390		0.382		0.621	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ ¹ Dependent variable is efficiency estimate obtained from DEA with VRS assumption, using judge size and total workload as inputs.² We also run the regression considering *CityTier* as category variable. Results are consistent.³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.⁴ Other controls include year dummy and dummies for each province.

Table 11: Second-stage panel regression result (CRS_2)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.022*** (0.006)	-0.023*** (0.006)	-0.026*** (0.007)	-0.028*** (0.007)	-0.021** (0.006)	-0.024*** (0.006)
CityTier ²	-0.014*** (0.002)	-0.015*** (0.002)	-0.013*** (0.003)	-0.015*** (0.002)	-0.009*** (0.002)	-0.011*** (0.002)
City_center ³						
County-level city	0.006 (0.006)	0.006 (0.006)	0.001 (0.008)	0.003 (0.007)	-0.002 (0.006)	-0.000 (0.006)
District	0.023*** (0.006)	0.020*** (0.005)	0.022** (0.007)	0.019** (0.007)	0.012 (0.006)	0.014* (0.006)
City_gov	0.018** (0.007)	0.019** (0.006)	0.018* (0.008)	0.020* (0.008)	0.007 (0.008)	0.010 (0.007)
log_Distance_P	-0.010*** (0.003)	-0.010** (0.003)	-0.009* (0.004)	-0.009* (0.004)	-0.004 (0.003)	-0.004 (0.003)
TotalWorkload1000	0.006*** (0.000)	0.006*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.007*** (0.000)	0.007*** (0.000)
log_Expenditure			0.030*** (0.007)	0.021*** (0.004)		
GDP_per_capita					0.011** (0.004)	0.006 (0.003)
Other controls ⁴						
sigma_u		0.046*** (0.001)		0.049*** (0.002)		0.039*** (0.002)
sigma_e		0.030*** (0.001)		0.027*** (0.001)		0.023*** (0.001)
N	1521	1521	1017	1017	872	872
R ²	0.783		0.766		0.823	
adj. R ²	0.775		0.754		0.814	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

¹ Dependent variable is efficiency estimate obtained from DEA with CRS assumption, using judge size and total workload as inputs.

² We also run the regression considering *CityTier* as category variable. Results are consistent.

³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.

⁴ Other controls include year dummy and dummies for each province.

Table 12: Second-stage panel regression result (CRS_2, Bootstrapped)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.021*** (0.006)	-0.023*** (0.006)	-0.026*** (0.007)	-0.027*** (0.007)	-0.021** (0.006)	-0.018** (0.006)
CityTier ²	-0.013*** (0.002)	-0.014*** (0.002)	-0.013*** (0.003)	-0.014*** (0.002)	-0.008*** (0.002)	0.000 (0.002)
City_center ³						
County-level city	0.006 (0.006)	0.006 (0.006)	0.001 (0.007)	0.003 (0.007)	-0.002 (0.006)	-0.008 (0.006)
District	0.022*** (0.005)	0.020*** (0.005)	0.021** (0.007)	0.019** (0.007)	0.011 (0.006)	0.018** (0.006)
City_gov	0.017** (0.006)	0.019** (0.006)	0.018* (0.008)	0.019* (0.008)	0.007 (0.007)	-0.012 (0.007)
log_Distance_P	-0.010*** (0.003)	-0.010** (0.003)	-0.009* (0.004)	-0.009* (0.004)	-0.004 (0.003)	0.001 (0.003)
TotalWorkload1000	0.006*** (0.000)	0.006*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.007*** (0.000)	0.007*** (0.000)
log_Expenditure			0.029*** (0.007)	0.021*** (0.004)		
GDP_per_capita					0.011** (0.004)	0.013*** (0.003)
Other controls ⁴						
sigma_u		0.045*** (0.001)		0.048*** (0.002)		0.038*** (0.002)
sigma_e		0.029*** (0.001)		0.026*** (0.001)		0.022*** (0.001)
N	1521	1521	1017	1017	872	872
R ²	0.783		0.766		0.823	
adj. R ²	0.775		0.754		0.814	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ ¹ Dependent variable is efficiency estimate obtained from DEA with CRS assumption, using judge size and total workload as inputs.² We also run the regression considering *CityTier* as category variable. Results are consistent.³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.⁴ Other controls include year dummy and dummies for each province.

Table 13: Second-stage panel regression result (VRS_2)¹

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Tobit	OLS	Tobit	OLS	Tobit
Lower_bar	-0.008 (0.007)	-0.010 (0.007)	-0.020** (0.007)	-0.018* (0.007)	-0.015* (0.006)	-0.018** (0.006)
CityTier ²	0.003 (0.002)	0.006** (0.002)	-0.009*** (0.003)	-0.002 (0.002)	0.002 (0.002)	0.000 (0.002)
City_center ³						
County-level city	-0.008 (0.007)	-0.007 (0.007)	-0.003 (0.007)	-0.001 (0.007)	-0.010 (0.006)	-0.008 (0.006)
District	0.032*** (0.006)	0.025*** (0.006)	0.031*** (0.007)	0.026*** (0.007)	0.015* (0.006)	0.018** (0.006)
City_gov	-0.013 (0.007)	-0.017* (0.007)	0.000 (0.008)	-0.008 (0.008)	-0.012 (0.007)	-0.012 (0.007)
log_Distance_P	-0.012*** (0.003)	-0.009** (0.003)	-0.013*** (0.004)	-0.010** (0.004)	0.000 (0.003)	0.001 (0.003)
TotalWorkload1000	0.006*** (0.000)	0.008*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.006*** (0.000)	0.007*** (0.000)
log_Expenditure			-0.051*** (0.007)	-0.019*** (0.005)		
GDP_per_capita					0.022*** (0.004)	0.013*** (0.003)
Other controls ⁴						
sigma_u		0.054*** (0.002)		0.048*** (0.002)		0.038*** (0.002)
sigma_e		0.028*** (0.001)		0.026*** (0.001)		0.022*** (0.001)
<i>N</i>	1521	1521	1017	1017	872	872
<i>R</i> ²	0.657		0.715		0.749	
adj. <i>R</i> ²	0.644		0.700		0.737	

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

¹ Dependent variable is efficiency estimate obtained from DEA with VRS assumption, using judge size and total workload as inputs.

² We also run the regression considering *CityTier* as category variable. Results are consistent.

³ The base category for *City_Center* is county, which is located outside the city center. County-level city is well developed county located outside the city center. The city center consists only of districts.

⁴ Other controls include year dummy and dummies for each province.