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Mototsugu FUKUSHIGE[†] and Yingxin SHI[‡]

Abstract

We investigate the effects of urban and rural populations and area sizes on the expenditures of the prefecture-level local government. We found the following three results. The first relates to the expenditure for urban populations. At around 220,000 people, per capita local government expenditure is minimized in our simulation. The second is that the expenditure for rural populations is proportional to the population size. The third finding is that the expenditure in accordance with the areas is also proportional to the area size. This cost structure is the reason why China’s recent rapid urbanization increases prefectural government’s fiscal distress.

JEL Classification: H40, H72, R51
Keywords: Efficient scale, Local government, Quantile regression, China

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1. Introduction

China has five layers of government including the central government. Each level of government, except the central government, receives financial transfers from the higher ranks of government and distributes the financial transfers to the lower levels of government. This system has operated since China’s national foundation. As for the tax collection system, the tax contracting system changed to the tax sharing system in 1994. In addition to these tax collecting and intergovernmental financial transfer systems, there is another set of financial resources for each level of government, for example, several kinds of charges or rental fees. These are extrabudgetary revenues and these finance the extrabudgetary expenditures for each level of government. There are several studies and explanations of this complex system. Ahmad (1997) reviews this system including its history, Bahl and Martinez-Vazquez (2006) summarize recent reforms to the system and Man (2011) focuses on the local financial system.

Recently, urbanization in China has been rapid and nationwide. This trend has induced additional demand for public expenditure at each level of local government. Most prefectural governments face financial problems. Tsui (2005) investigated the effects of intergovernmental fiscal transfers on the equalization of fiscal expenditures across counties. To remove or reduce such financial distress, several researchers have suggested several kinds of reforms of local government fiscal systems or intergovernmental transfer systems; for example, the World Bank (2007) discussed the reforms to China’s tax system and intergovernmental fiscal system and transfer totally and Bahl (2011) examined decentralization and revenue assignment.

However, most studies have proposed changes to the intergovernmental financial transfer system or tax revenue systems. Few of them mention the adequacy of the five-layer government system or optimal level or size of local government or local government's roles in providing public goods or services. Prefecture populations vary from 7,000 to 2,239,000 and prefecture areas vary from 86 km^2 to 198,318 km^2.[1] Some prefectures consist only of farmers and others have relatively large urban populations. Additionally, there are some prefectural governments in metropolitan areas, including Tianjin and Shanghai. In such cases, it might be impossible to develop a reform that maintains the sizes or systems of prefectures. In this paper, to evaluate the adequacy of the five-layer local government system, we investigate the efficient scale of prefectures from a minimizing government expenditures viewpoint, using data from 2037 prefectures, which excludes some prefectures within metropolitan areas and missing observations.

Following several previous studies, we consider whether local government expenditures are determined by local population and area size. Most prefectures, however, are composed of both urban and rural areas, so we assume that local government expenditures depend on urban and rural populations and area size. We also assume that the total amount of government expenditures is determined by a quartic function of each factor. This assumption corresponds to the assumption that per capita expenditures is a cubic function. The reason why we assume a cubic function for per capita expenditures is that several previous studies assumed a U-shaped function for per capita expenditures for several public services or costs. Additionally, by allowing a nonsymmetrical U-shaped function for per capita expenditures in levels to capture the asymmetric marginal effects below and above the lowest (optimal) point, we assume a cubic function.[2] In the

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[1] These population and area data are minimums and maximums in the sample used in this paper.

[2] Some researchers overcome this problem by logarithmic transformation of per capita expenditures and explanatory factors and a quadratic function, which is symmetric around the minimum point.

estimation process, we find too much variation in per capita expenditures even when we control several factors, so we apply a quantile regression approach to the data. From the estimated results, we analyze the efficient scales for urban and rural populations and area size.

The paper proceeds as follows. In Section 2, we conduct a short literature survey on the efficient scale for local government or several kinds of public services or costs. In Section 3, we introduce our econometric model to analyze aggregated prefectural expenditures. In Section 4, we conduct OLS estimation and diagnostics on the residuals. In Section 5, we present the results of a quantile regression. We simulate the efficient scales for urban and rural populations and areas in Section 6. Finally, we discuss some shortcomings of our paper and possibilities for future research in Section 7.

2. Literature Survey of Efficient Scale of Local Governments

Oates (1972) examined fiscal federalism and several subsequent studies investigated systems of local public finance. Some of these studies, such as Alesina and Spolare (2003), examined the optimal size of governments or nations. Others authors have discussed the optimal combination or layers of local governments, for example, Hochman, Pines and Thisse (1995) and Baleiras (2001).[3] To investigate the real size of local governments, we must first examine the cost structures of local public services. The empirical analysis of Shelton (2007), which investigated the determinants of central and local governments' total expenditure and expenditures on some specific items using

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[3] King and Ma (2000) investigated theoretically the relationship between congestion and the size of local government.

international data, focused on the optimal allocation of service provisions among central and local governments.

Many papers have examined the cost structure or efficiency of providing local public services. Most of these studies attempt to investigate the cost structures of specific public services such as the police or fire department, schools, sewage or water supply services and so on. For example, Hirsch (1959) investigated total expenditure on police services, refuse collection, fire protection and education services. He fitted a quadratic function of population and found inverted U-shaped relationships with various kinds of expenditures, which suggests the existence of economies of scale. Bodkin and Conklin (1971) conducted a similar analysis on per capita local public expenditures. They found a U-shaped relationship between per capita total expenditure and population, but did not find U-shaped relationships with some specific public expenditure items. Beaton (1974) fitted linear regression equations to the cost of police services by population size of cities. Borcherding and Deacon (1972) also fitted simple log-linear equations to several outputs of public services. Craig (1987), Craig and Heikkila (1989) and Edwards (1990) introduced congestion functions and estimated the degrees of congestion in providing public safety and others. Ladd (1992) estimated a piecewise linear function and obtained asymmetric U-shaped cost function. Solé-Ollé and Bosch (2005) took a similar approach. Duncombe, Miner and Ruggiero (1995) also found asymmetric relationships between school size and expenditures. Several studies have fitted quadratic functions to the cost structure of local public services: Hirsch (1965) for refuse collections, Knapp (1982) for crematoria and Tao and Yuan (2005) for public elementary schools. Furthermore, in relation to other aspects of cost structures, Ladd (1994) and Nelson (1992) investigated the relationship between population growth and counties’ expenditures. Carruthers and

Ulfarsson (2003) investigated the effects of population growth and changes in population densities from the aspect of urban sprawl. Duncombe and Yinger (1993) extended this type of analysis to multiple types of public services and estimated the degree of economies of scope. Au and Henderson (2006) focused on the agglomeration effect of cities in China and estimated an inverted U-shaped function for productivity.[4]

When we estimate the cost structure of specific public services, we cannot determine the optimal size of the local government. However, this type of research provides evidence regarding which level or layer of government should supply police or other specific public services. When we estimate the total expenditure function, we can directly investigate the efficient scale of the local government. However, this type of analysis is limited by the existing roles of local government within the current central–local government system.

In this paper, we investigate the efficient scale of prefectural government; thus, our paper adopts the latter type of analysis. According to Martinez-Vazquez and Qiao (2011), prefectural government mainly provides services related to public security, social security and health care within the current five-layer government system in China. As for the prefectural government's expenditure shares, the top four items are capital investment, education, government administration and public security. We cannot obtain each prefecture's detailed fiscal expenditures. This is another reason why we cannot apply the former type of studies to some specific public services. In this paper, we assume that total prefectural expenditures also have U-shaped cost structures as do specific expenditures, *e.g.*, public security, education or government administration.

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[4] Additionally, Andrews, Duncombe and Yinger (2002) conducted a literature survey of economies of scale in public education provision.

3. Econometric Model for Aggregated Data

The details of local government expenditures are not available. We only have budgetary expenditures and extrabudgetary expenditures in total. Therefore, we investigate the determinants of total budgetary and extrabudgetary expenditures (G). We assume this total expenditure consists of three components: expenditure for urban population ($\mathrm{G_U}$), expenditure for rural population ($\mathrm{G_A}$) and expenditure related to area size ($\mathrm{G_S}$):

$$\mathrm{G}=\mathrm{G_U}+\mathrm{G_A}+.\,\mathrm{G_S}.$$

Then, each of these three components is a quartic function of each factor:

$$\mathrm{G_U}=\alpha_0+\alpha_1\mathrm{UPop}+\alpha_2\mathrm{UPop}^2+\alpha_3\mathrm{UPop}^{.3}\alpha_4\mathrm{UPop}^{.4},$$

$$\mathrm{G_A}=\beta_0+\beta_1\mathrm{RPop}+\beta_2\mathrm{RPop}^2+\beta_3\mathrm{RPop}^3+\beta_4\mathrm{RPop}^4,$$

$$\mathrm{G_S}=\gamma_0+\gamma_1\mathrm{Area}+\gamma_2\mathrm{Area}^2+\gamma_3\mathrm{Area}^3+\gamma_4\mathrm{Area}^4,$$

where UPop, RPop and Area are urban population, rural population and area size, respectively. We can write the equation for per capita expenditures as follows:

$$\begin{aligned}\frac{\mathrm{G}}{\mathrm{Pop}} \quad = \quad & \frac{\alpha_0}{\mathrm{Pop}} + \alpha_1 \frac{\mathrm{UPop}}{\mathrm{Pop}} + \alpha_2 \frac{\mathrm{UPop}^2}{\mathrm{Pop}} + \alpha_3 \frac{\mathrm{UPop}^3}{\mathrm{Pop}} + \alpha_4 \frac{\mathrm{UPop}^4}{\mathrm{Pop}} \\ & + \frac{\beta_1}{\mathrm{Pop}} + \beta_1 \frac{\mathrm{RPop}}{\mathrm{Pop}} + \beta_2 \frac{\mathrm{RPop}^2}{\mathrm{Pop}} + \beta_3 \frac{\mathrm{RPop}^3}{\mathrm{Pop}} + \beta_4 \frac{\mathrm{RPop}^4}{\mathrm{Pop}}, \\ & + \frac{\gamma_0}{\mathrm{Pop}} + \gamma_1 \frac{\mathrm{Area}}{\mathrm{Pop}} + \gamma_2 \frac{\mathrm{Area}^2}{\mathrm{Pop}} + \gamma_3 \frac{\mathrm{Area}^3}{\mathrm{Pop}} + \gamma_4 \frac{\mathrm{Area}^4}{\mathrm{Pop}}\end{aligned}$$

and this equation can be rewritten as

$$\begin{aligned}\frac{\mathrm{G}}{\mathrm{Pop}} \quad = \quad & \frac{\delta}{\mathrm{Pop}} + \alpha_1 \frac{\mathrm{UPop}}{\mathrm{Pop}} + \alpha_2 \frac{\mathrm{UPop}^2}{\mathrm{Pop}} + \alpha_3 \frac{\mathrm{UPop}^3}{\mathrm{Pop}} + \alpha_4 \frac{\mathrm{UPop}^4}{\mathrm{Pop}} \\ & + \beta_1 \frac{\mathrm{RPop}}{\mathrm{Pop}} + \beta_2 \frac{\mathrm{RPop}^2}{\mathrm{Pop}} + \beta_3 \frac{\mathrm{RPop}^3}{\mathrm{Pop}} + \beta_4 \frac{\mathrm{RPop}^4}{\mathrm{Pop}} \\ & + \gamma_1 \frac{\mathrm{Area}}{\mathrm{Pop}} + \gamma_2 \frac{\mathrm{Area}^2}{\mathrm{Pop}} + \gamma_3 \frac{\mathrm{Area}^3}{\mathrm{Pop}} + \gamma_4 \frac{\mathrm{Area}^4}{\mathrm{Pop}}\end{aligned}$$

using the following reparameterization:

$$\delta = \alpha_0 + \beta_0 + \gamma_0.$$

The relation between total population (Pop) and urban and rural populations,

$$\mathrm{Pop} = \mathrm{UPop} + \mathrm{RPop},$$

leads to

$$1 = \frac{\mathrm{UPop}}{\mathrm{Pop}} + \frac{\mathrm{RPop}}{\mathrm{Pop}}$$

and we can rewrite the equation and add the error term as

$$\begin{aligned}\frac{\mathrm{G}}{\mathrm{Pop}} = \alpha_1 + \delta\frac{1}{\mathrm{Pop}} + \alpha_2\frac{\mathrm{UPop}^2}{\mathrm{Pop}} + \alpha_3\frac{\mathrm{UPop}^3}{\mathrm{Pop}} + \alpha_4\frac{\mathrm{UPop}^4}{\mathrm{Pop}} \\ + (\beta_1 - \alpha_1)\frac{\mathrm{RPop}}{\mathrm{Pop}} + \beta_2\frac{\mathrm{RPop}^2}{\mathrm{Pop}} + \beta_3\frac{\mathrm{RPop}^3}{\mathrm{Pop}} + \beta_4\frac{\mathrm{RPop}^4}{\mathrm{Pop}} \\ + \gamma_1\frac{\mathrm{Area}}{\mathrm{Pop}} + \gamma_2\frac{\mathrm{Area}^2}{\mathrm{Pop}} + \gamma_3\frac{\mathrm{Area}^3}{\mathrm{Pop}} + \gamma_4\frac{\mathrm{Area}^4}{\mathrm{Pop}} + \mathrm{u}.\end{aligned}$$

Furthermore, we introduce a reparameterization of

$$\phi = \beta_1 - \alpha_1$$

and an additional factor to determine the expenditures: number of towns or villages in each prefecture (NTowns). Finally, we obtain the estimation equation:

$$\begin{aligned}\frac{\mathrm{G}}{\mathrm{Pop}} = \alpha_1 + \theta\frac{\mathrm{NTowns}}{\mathrm{Pop}} + \delta\frac{1}{\mathrm{Pop}} + \alpha_2\frac{\mathrm{UPop}^2}{\mathrm{Pop}} + \alpha_3\frac{\mathrm{UPop}^3}{\mathrm{Pop}} + \alpha_4\frac{\mathrm{UPop}^4}{\mathrm{Pop}} \\ + \phi\frac{\mathrm{RPop}}{\mathrm{Pop}} + \beta_2\frac{\mathrm{RPop}^2}{\mathrm{Pop}} + \beta_3\frac{\mathrm{RPop}^3}{\mathrm{Pop}} + \beta_4\frac{\mathrm{RPop}^4}{\mathrm{Pop}} \qquad (1) \\ + \gamma_1\frac{\mathrm{Area}}{\mathrm{Pop}} + \gamma_2\frac{\mathrm{Area}^2}{\mathrm{Pop}} + \gamma_3\frac{\mathrm{Area}^3}{\mathrm{Pop}} + \gamma_4\frac{\mathrm{Area}^4}{\mathrm{Pop}} + \mathrm{u}\ .\end{aligned}$$

The reason why we introduce NTowns as an additional explanatory variable is that each prefecture makes fiscal transfers to towns or villages within the prefectures and each town or village has fixed costs associated with the provision of their public services. In the following sections, we estimate this equation (1) by OLS or another estimation method.

4. Data and OLS Estimation

In this section, we report the estimation results of equation (1) by OLS. Before exploring the results, we describe the data used in this paper. We use data for 2037 prefectures in the estimation. The coverage and sample size in each province or municipality are shown in Table 1. The coverage of our sample is 71.3% because we delete the data of prefectures within metropolitan areas and some missing data exist. We collect data for urban and rural populations and area size from the 2009 China County Statistical Yearbook and prefectures' budgetary and extrabudgetary expenditures[5] from the 2009 National Prefecture, City, County Fiscal Statistical Book. Summary statistics of the data are shown in Table 2. The measurement units of the data are as follows: G is in 10,000 yuan, Pop, UPop and RPop are in 10,000 people, Area is in square kilometers and NTowns is in number of towns. Table 2 also shows the summary statistics for the transformed data.

Table 3 shows the results of the OLS estimation. Some coefficients are estimated as being statistically significant, whereas others are insignificant. The coefficient of determination (R^2) is 0.49. This is relatively high for this type of cross-sectional data analysis. However, tests for heteroskedasticity (LM-hetero) and misspecification (RESET) imply misspecification or crucial heteroskedasticity. Jarque–Bera's test for nonnormality of the error terms implies that the distribution of error terms cannot be

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[5] This total expenditure includes budgetary and extrabudgetary expenditures and expenditures of governmental funds in each prefecture.

normal. Robust t-values are estimated t-values calculated as White's heteroskedasticity-consistent standard errors. The calculated standard t-values and robust t-values are different, so these results also suggest the existence of heteroskedasticity in the error terms. Then, we plot the fitted values of the regression equation and residuals in Figure 1 to check the distribution of the error terms. This figure implies that the error terms are asymmetric and heteroskedastic. Some of the residuals imply the existence of outliers. A similar result is found in Solé-Ollé and Bosch (2005, Figure 2, p. 354). They dealt with this type of problem by applying a piecewise linear regression model. In this paper, we apply a quantile regression in the next section.

5. Quantile Regression Approach

A well-known text on quantile regression is Koenker (2005). This method is usually applied when the error term has heteroskedasticity with respect to the levels of the dependent variables. In this paper, we apply this method to multiple regression models with a quartic function. Details of this procedure are available in Koenker (2005); however, to summarize this method we assume a linear regression model with an error term as follows:

$$\mathrm{y}_i = \mathrm{X}_i'\beta + \varepsilon_{i,}, \qquad i = 1,2,3,\dots,N.$$

When we estimate the OLS estimator, we minimize the following objective function:

$$\mathrm{S}(\beta) = \sum_{i=1}^{N} (\mathrm{y}_i - \mathrm{X}_i'\beta\,)^2\ .$$

As for the quantile regression, we set a quantile μ_q and q as follows:

$$\mathrm{q} = \Pr\left(\mathrm{y}_i \leq \mu_q\right) = F_y\left(\mu_q\right),$$

where $F_y\left(\mu_q\right)$ is the distribution function of y_i. Of course, the inverse function of $F_y\left(\mu_q\right)$ means

$$\mu_q = {F_y}^{-1}(\mathrm{q}).$$

If we assume $\mathrm{y}_i = \mathrm{X}_i'\beta + \varepsilon_{i,}$ this inverse function could be rewritten in terms of conditional probability as follows:

$$\mu_q(X) = {F_{y|X}}^{-1}(\mathrm{q}).$$

To estimate β_q in a quantile regression requires minimization of the following objective function with respect to β_q:

$$\mathrm{S}\left(\beta_q\right) = \sum_{i:\, \mathrm{y}_i \geq \mathrm{X}_i'\beta}^{N} q\left|\mathrm{y}_i - \mathrm{X}_i'\beta_q\right| + \sum_{i:\, \mathrm{y}_i < \mathrm{X}_i'\beta}^{N} (1-q)\left|\mathrm{y}_i - \mathrm{X}_i'\beta_q\right|.$$

This is a variation of least absolute deviation (LAD) estimation. There exist various methods to estimate the standard errors of the estimated parameters. In this paper, we use the LAD command in TSP version 5.0. This command estimates the standard errors of the coefficient using a bootstrap method with 500 replications.

The results of the quantile regression when we estimate equation (1) with q = 0.1, 0.25, 0.5, 0.75 and 0.9 are shown in Table 4. The results show that some coefficients are not statistically significant at the 5% level in all settings of q, so we remove the corresponding variables from the equation and reestimate the model. The results are shown in Table 5 as the selected model. This table shows the OLS estimation results using the same list of explanatory variables. In the next section, using these results, we simulate the effects of UPop, RPop and Area on ${}^{G}/_{Pop}$. This type of simulation makes the robustness of the existence of the efficient scales.

6. Simulation for Efficient Scales

To simulate the effects of changes in the explanatory variables in the multiple regression equation, we should control all explanatory variables other than the variable of focus. In this section, we investigate the effects of UPop, RPop and Area on ${}^{G}/_{Pop}$. For the former two populations, we assume a situation in which all the people in the prefectures live either in the urban or in the rural area: Pop $=$ UPop or Pop $=$ RPop.

First, we simulate the effects of urban population assuming Pop $=$ UPop and setting the area and number of towns or villages under each prefecture at their average values: Area $= \overline{Area}$ and NTowns $= \overline{NTowns}$. Then, we calculate the effect of urban population on the per capita government expenditures corresponding to the changes in population as follows:

$$\frac{\widehat{G}}{Pop}(Pop) = \widehat{\alpha_1} + \hat{\theta}\frac{\overline{NTowns}}{Pop} + \hat{\delta}\frac{1}{Pop} + \widehat{\alpha_2}Pop + \widehat{\alpha_3}Pop^2 + \widehat{\alpha_4}Pop^3$$
$$+\widehat{\gamma}_1\frac{\overline{Area}}{Pop} + \widehat{\gamma}_2\frac{\overline{Area^2}}{Pop} + \widehat{\gamma}_3\frac{\overline{Area^3}}{Pop} + \widehat{\gamma}_4\frac{\overline{Area^4}}{Pop},$$

where the parameters with hats are estimates and the variables with upper bars are average values. While the distribution of total populations ranges between zero and 2,250,000 people (Figure 2), urban populations are distributed between zero and 620,000 people (Figure 3). Therefore, we figure the calculated per capita expenditures from 2,550 to 400,000 people in Figure 4. From this figure, we can observe that there exist the points to minimize the per capita expenditures in all the regression results: OLS, quantile regressions with q = 0.1, 0.25, 0.5, 0.75 and 0.9. The calculated points that minimize per capita expenditures are as follows:

OLS : 212,000
$q = 0.1$: 264,500
$q = 0.25$: 243,500
$q = 0.5$: 237,500
$q = 0.75$: 210,000
$q = 0.9$: 170,500.

There exists a variation according to the setting of q, but it is located between 170,000 and 270,000 people. In particular, for the q = 0.5 and OLS cases, the points are located mainly around 220,000 people. These results suggest that there is a most efficient scale for the urban population and it is located around 220,000 people. If q goes to zero asymptotically, this method becomes similar to that of corrected least square (COLS) in econometrics for efficiency and productivity.[6] Therefore, if we assume that the case of q = 0.1 is the lower 10% efficient prefectures results, the most efficient prefectures minimize their expenditures when their urban populations are equal to or greater than 264,500 people.

Second, we simulate the effects of the rural population assuming Pop $=$ APop and setting the area and number of towns or villages in each prefecture at their average values: Area $= \overline{Area}$ and NTowns $= \overline{NTowns}$. Then, we calculate the effect of the rural population on per capita government expenditures when the population changes as follows:

$$\frac{\widehat{G}}{Pop}(Pop) = \widehat{\alpha_1} + \hat{\theta}\frac{\overline{NTowns}}{Pop} + \hat{\delta}\frac{1}{Pop} + \hat{\phi} + \widehat{\beta_2}Pop + \widehat{\beta_3}Pop^2 + \widehat{\beta_4}Pop^3$$
$$+\widehat{\gamma}_1\frac{\overline{Area}}{Pop} + \widehat{\gamma}_2\frac{\overline{Area^2}}{Pop} + \widehat{\gamma}_3\frac{\overline{Area^3}}{Pop} + \widehat{\gamma}_4\frac{\overline{Area^4}}{Pop}.$$

Rural population distributes between zero and 1,950,000 people (Figure 5). Therefore, we figure the calculated per capita expenditures from 10,000 to 1,500,000 people in Figure 6. In this figure, some simulated lines cross in the range between 10,000 and 100,000 people; this phenomenon is caused by fixing the number of towns or villages under each prefecture at their average values, Area $= \overline{Area}$ and NTowns $= \overline{NTowns}$, with estimated coefficients for the higher-order quartic equation being statistically insignificant. Therefore, we do not investigate small rural population cases. When the population is 100,000 and over, per capita expenditures are slightly decreasing when q =

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[6] Winsten (1957) first proposed this method. It is referred to as COLS in the econometrics of efficiency and productivity literature; for example, Fried *et al*. (2008, p. 35) explains this method.

0.1, 0.25, 0.5 and 0.75 and slightly increasing when q = 0.95, and flat in the OLS case. These results suggest that government expenditures for rural populations vary in proportion to population size. Furthermore, we should pay attention to the simulated level of expenditures. Comparing the simulated expenditures for rural populations with those for urban populations, we see the former are much smaller than the latter. For example, the former are about 1300 yuan, whereas the latter do not fall below 5000 yuan in the q = 0.5 case. This means that the prefectural government that governs a rural population operates cost-effectively.

Third, we simulate the effects of area holding the ratios of urban population and rural population to total population at their average values: $\mathrm{APop}/\mathrm{Pop} = \overline{\mathrm{APop}/\mathrm{Pop}}$ and $\mathrm{UPop}/\mathrm{Pop} = \overline{\mathrm{UPop}/\mathrm{Pop}}$, and the number of towns or villages in each prefecture at their average values, $\mathrm{NTowns} = \overline{NTowns}$. Then, we calculate the effect of area on per capita government expenditures corresponding to changes in area as follows:

$$\begin{aligned}\frac{\widehat{G}}{Pop}(Area) = \widehat{\alpha_1} + \hat{\theta}\frac{\overline{NTowns}}{Pop} + \hat{\delta}\frac{\overline{1}}{Pop} + \widehat{\alpha_2}\frac{\overline{UPop^2}}{Pop} + \widehat{\alpha_3}\frac{\overline{UPop^3}}{Pop} \\ + \widehat{\alpha_4}\frac{\overline{UPop^4}}{Pop} \\ + \hat{\phi}\frac{\overline{RPop}}{Pop} + \widehat{\beta_2}\frac{\overline{RPop^2}}{Pop} + \widehat{\beta_3}\frac{\overline{RPop^3}}{Pop} + \widehat{\beta_4}\frac{\overline{RPop^4}}{Pop} \\ + \widehat{\gamma_1}\frac{Area}{Pop} + \widehat{\gamma_2}\frac{Area^2}{Pop} + \widehat{\gamma_3}\frac{Area^3}{Pop} \\ + \widehat{\gamma_4}\frac{Area^4}{Pop}.\end{aligned}$$

Area is distributed between zero and over 20,000 km^2 (Figure 7). Therefore, we calculate per capita expenditures from 389 km^2 to 16,000 km^2 in Figure 8. The results indicate that per capita expenditures are increasing slightly in all cases but at a slow rate. These results suggest that government expenditures corresponding to area are determined in proportion to area size.

7. Conclusion

We investigated the effects of urban and rural populations and area size on the expenditures of the prefectural-level local government. Throughout the empirical investigation, we found the following three results. First, at around 220,000 people, per capita local government expenditure for urban populations has a minimum value in our simulation. This can also be seen in the simulation results from the quantile regression. Second, expenditure for rural populations is proportional to population size. Additionally, per capita expenditures are much lower than those for urban populations. Third, expenditure corresponding to area is also proportional to area size. The last two findings mean that the expenditures are proportional to population and area size when all the prefectural populations are rural. If we consider these results from another viewpoint, China’s recent rapid urbanization has increased prefectural government expenditures substantially. It has also caused fiscal distress among prefectural governments. Lichtenberg and Ding (2009) also discussed the present trend of land conversion from rural to urban use and the associated problems.

It is of course impossible to stop the current urbanization trend in China. However, prefectures that are heavily urbanized should be divided into prefectures of efficient size, each of which consists of around 220,000 people, and rural populations. This is similar to the concept of the “garden city” in urban planning, which was examined by Ward (1992). To consider the level of economic development, it should be called "rural city."[7] Apart from metropolitan areas, the construction of rural cities from coast to coast should be the best way to control prefectural government expenditures. However, this may contradict the findings of Au and Henderson (2006), which showed that more than half of Chinese cities are undersized from the viewpoint of agglomeration effects on workers' productivity. If further migration from rural areas to cities increases wages further, it is difficult to maintain the urban population in each prefecture at around 220,000. If the Chinese central or local governments cannot control migration, they should increase tax revenues or find other revenue sources to finance prefectural government expenditures. Recent measures to reform resource-related taxation in China are an example of the search for new revenue sources.

Finally, our study has some limitations. First, as we explained in the introduction, we cannot investigate the efficient scales of specific public expenditures such as police and fire departments or water supply. If we were able to investigate each type of expenditure, we could consider the assignment of public services among the five layers of government or the efficient structures of local government systems. We could also investigate economies of scale in public expenditures for each item and economies of scope among several types of public expenditure. For example, Drake and Simper (2002) emphasize the existence of economies of scope in public service expenditures. The second remaining problem is a result of the quantile regression approach. The results also shed light on the existence of the large difference in expenditure between governments of similar size but in prefectures with differences in terms of urban or rural populations and area size. This means that some governments spend considerably more than others and

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[7] Chen *et al.* (2008) proposed the "compact city" for sustainable growth in China, focusing on land saving; thus, it is different from the concept of our "rural city."

some spend considerably less. Such differences should be investigated to identify the specific reason or factor for this by prefecture. Additionally, if we obtain prefectural socioeconomic statistics, which were used by Gyimah-Brempong (1989) to examine the determinants of the cost of providing public safety, they could help identify the sources of variation in prefectural expenditures and provide the comparable efficiency ranking within similar size prefectures.

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Table 1. Coverage of sample for each province or municipality

Provinces and municipalities	Sample	Total	Coverage
Beijing Municipality	5	18	0.278
Tianjin Municipality	4	16	0.250
Hubei Province	138	172	0.802
Shanxi Province	97	119	0.815
Inner Mongolia Autonomous Region	81	101	0.802
Liaoning Province	43	100	0.430
Jilin Province	41	60	0.683
Heilongjiang Province	65	128	0.508
Shanghai Municipality	3	18	0.167
Jiangsu Province	57	106	0.538
Zhejiang Province	55	90	0.611
Anhui Province	61	105	0.581
Fijian Province	57	85	0.671
Jiangxi Province	80	99	0.808
Shandong Province	91	140	0.650
Henan Province	107	159	0.673
Hubei Province	66	103	0.641
Hunan Province	84	122	0.689
Guangdong Province	74	121	0.612
Guangxi Province	81	109	0.743
Hainan Province	16	20	0.800
Changing Municipality	26	40	0.650
Sichuan Province	139	181	0.768
Guizot Province	76	88	0.864
Yunnan Province	120	129	0.930
Tibet Autonomous Region	72	73	0.986
Shaanxi Province	86	107	0.804
Gansu Province	75	86	0.872
Qinghai Province	38	43	0.884
Ningxia Hui Autonomous Region	13	22	0.591
Xinjiang Uygur Autonomous Region	86	98	0.878
Total	2037	2858	0.713

Note 1: Total is the total number of county-level jurisdictions in 2009 reported by the 2010 China Statistical Yearbook.

Note 2: Sample is the number of observations used in this paper and coverage is the coverage ratio of the “sample” to the “total.”

Table 2. Summary Statistics

Variables	Mean	Standard deviation	Minimum	Maximum
Original data				
G	118863.8	104488.1	300	1504195
Pop	47.31635	34.89929	0.7	223.9
$RPop$	38.76117	30.29445	0.1	193.6
$Area$	4294.808	9945.455	86	198318
$NTowns$	14.70201	7.995951	1	72
Transformed data				
$\frac{G}{Pop}$	3363.36	2814.228	34.09091	34087.64
$\frac{1}{Pop}$	0.054245	0.10624	0.004466	1.42857
$\frac{UPop}{Pop}$	0.20093	0.14346	0	0.99342
$\frac{RPop}{Pop}$	0.79907	0.14346	0.006579	1
$\frac{Area}{Pop}$	644.5605	4058.228	2.56667	85662.23
$\frac{NTowns}{Pop}$	0.5652	0.76666	0.031646	8.57143

Table 3. Estimation Results by OLS

	Coefficient	t-value	Robust t-value
Constant	19860.4	**23.842**	**10.526**
$\frac{NTowns}{Pop}$	1002.82	**7.980**	**4.573**
$\frac{1}{Pop}$	115.802	0.090	0.005
$\frac{UPop^2}{Pop}$	–1621.85	**–13.424**	**–6.543**
$\frac{UPop^3}{Pop}$	56.5807	**10.917**	**5.849**
$\frac{UPop^4}{Pop}$	–0.57576	**–9.4678**	**–5.485**
$\frac{RPop}{Pop}$	–19200.8	**–18.218**	**–8.712**
$\frac{RPop^2}{Pop}$	0.095896	0.006	0.003
$\frac{RPop^3}{Pop}$	0.084069	0.387	0.273
$\frac{RPop^4}{Pop}$	–0.00066	–0.710	–0.637
$\frac{Area}{Pop}$	0.178648	1.580	0.051
$\frac{Area^2}{Pop}$	–2.5E-06	–0.777	–0.021
$\frac{Area^3}{Pop}$	2.58E-11	0.810	0.021
$\frac{Area^4}{Pop}$	–8.9E-17	–0.960	–0.024
Adj R^2	0.4987		
LM-hetero	**85.507**		
RESET	**52.927**		
Jarque–Bera	**75719.2**		

Note 1: Adj R^2, LM-hetero, RESET and Jarque–Bera are adjusted R-squared, test for heteroskedasticity, RESET test with squared fitted values and Jarque–Bera test for normality.

Note 2: Bold values mean statistically significant at the 5% level.

Table 4. Estimation Results by Quantile Regression: Full Model

Quantiles	0.10	0.25	0.5	0.75	0.90
Constant	**8437.364**	**10865.07**	**14691.87**	**18867.71**	**25474.17**
$\frac{NTowns}{Pop}$	186.2419	200.8443	**472.8929**	**1246.982**	**2323.414**
$\frac{1}{Pop}$	2790.369	2072.114	**1612.773**	–256.541	–2870.05
$\frac{UPop^2}{Pop}$	**–582.815**	**–790.664**	**–1124.87**	**–1489.6**	**–2170.34**
$\frac{UPop^3}{Pop}$	17.69066	**25.17713**	**37.11554**	**52.52024**	**88.6423**
$\frac{UPop^4}{Pop}$	–0.1602	**–0.24401**	**–0.36007**	**–0.5324**	**–0.96903**
$\frac{RPop}{Pop}$	**–6867.2**	**–9253.76**	**–13284.8**	**–17565.5**	**–24829.6**
$\frac{RPop^2}{Pop}$	–25.0469	–22.1984	–14.4934	–13.016	7.5451
$\frac{RPop^3}{Pop}$	0.27828	0.22899	0.12407	0.16248	0.016699
$\frac{RPop^4}{Pop}$	–0.00109	–0.00086	–0.00042	–0.00069	–0.00042
$\frac{Area}{Pop}$	0.12069	**0.29961**	**0.4339**	**0.43212**	0.36434
$\frac{Area^2}{Pop}$	–2.17E-06	–4.66E-06	**–7.83E-06**	**–8.46E-06**	–7.46E-06
$\frac{Area^3}{Pop}$	8.35E-12	1.92E-11	**4.93E-11**	**9.98E-11**	8.28E-11
$\frac{Area^4}{Pop}$	1.17E-17	–5.10E-18	**–9.84E-17**	**–3.44E-16**	–2.85E-16
Adj R^2	0.46307	0.47224	0.48437	0.48294	0.47717

Note 1: Adj R^2 is adjusted R-squared.

Note 2: Bold values mean statistically significant at the 5% level.

Table 5. Estimation Results by Quantile Regression: Selected Model

Quantiles	0.10	0.25	0.5	0.75	0.90	OLS
Constant	**9865.556**	**12879.36**	**16433.2**	**19494.19**	**23919.46**	**19595.94**
$\frac{NTowns}{Pop}$	372.7542	**310.7989**	**594.6125**	**1329.612**	2163.313	**980.2919**
$\frac{1}{Pop}$	2965.341	**3612.943**	**1550.574**	1299.058	–3512.63	5.34297
$\frac{UPop^2}{Pop}$	**–708.287**	**–1004.27**	**–1298.16**	**–1540.59**	**–1887.98**	**–1590.68**
$\frac{UPop^3}{Pop}$	**20.67388**	**32.16626**	**42.61537**	**53.8526**	**76.49473**	**55.56158**
$\frac{UPop^4}{Pop}$	–0.18161	**–0.31268**	**–0.41115**	**–0.54328**	**–0.83928**	**–0.56619**
$\frac{RPop}{Pop}$	**–9113.59**	**–12080.4**	**–15627.1**	**–18605.9**	**–22888.9**	**–18819.8**
$\frac{Area}{Pop}$	0.12268	0.18421	**0.39747**	**0.27226**	0.44509	0.19418
$\frac{Area^2}{Pop}$	–2.88E-06	–2.83E-06	**–7.61E-06**	–4.83E-06	–7.99E-06	–2.9E-06
$\frac{Area^3}{Pop}$	1.73E-11	9.67E-12	**4.85E-11**	**6.95E-11**	8.22E-11	2.84E-11
$\frac{Area^4}{Pop}$	–1.77E-17	8.49E-18	**–9.67E-17**	**–2.65E-16**	–2.77E-16	–9.6E-17
R^2	0.46899	0.4791	0.48777	0.48514	0.47876	0.50135

Note 1: R^2 is R-squared.

Note 2: Bold values mean statistically significant at the 5% level.

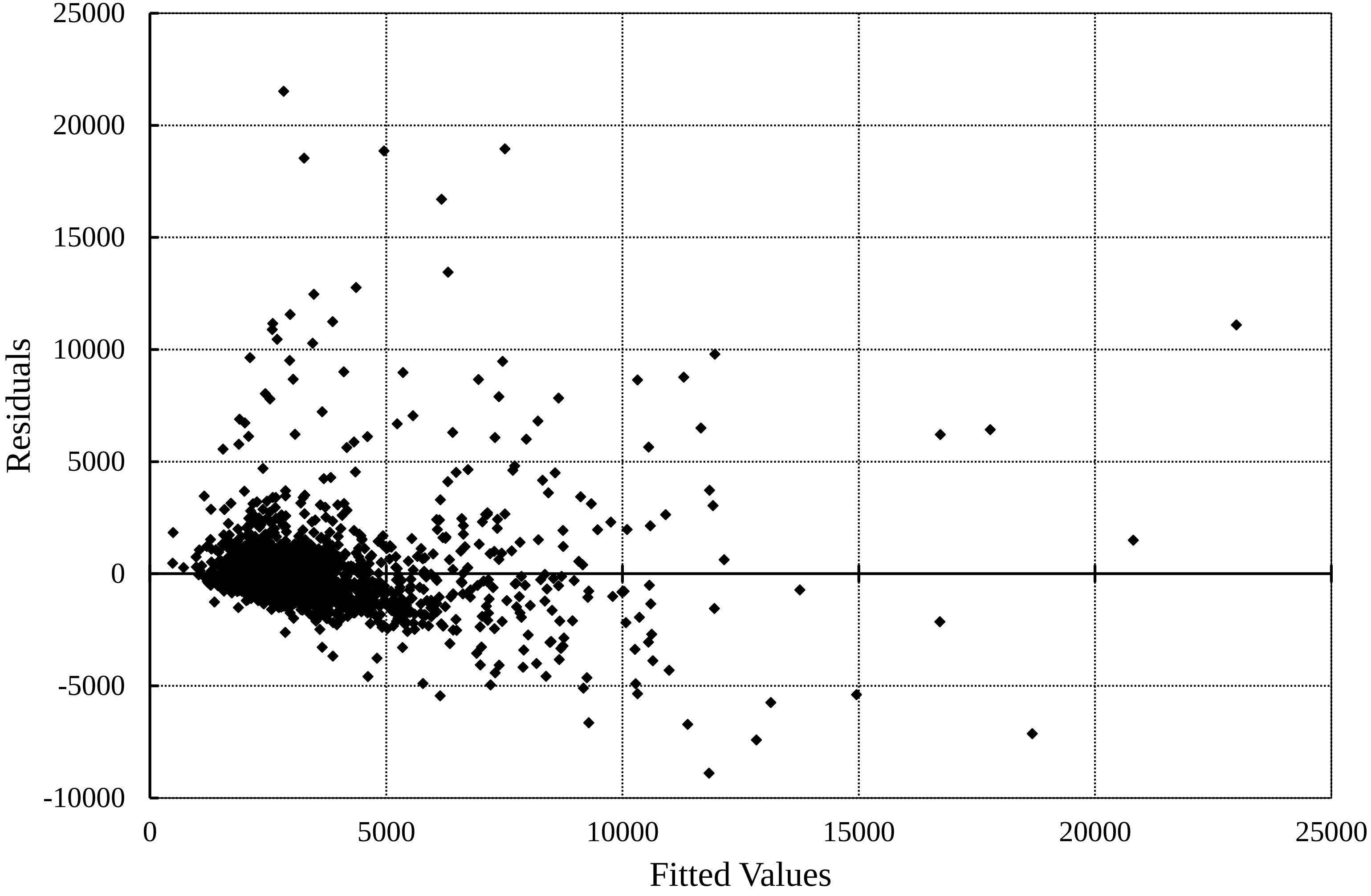

Figure 1. Fitted values and residuals

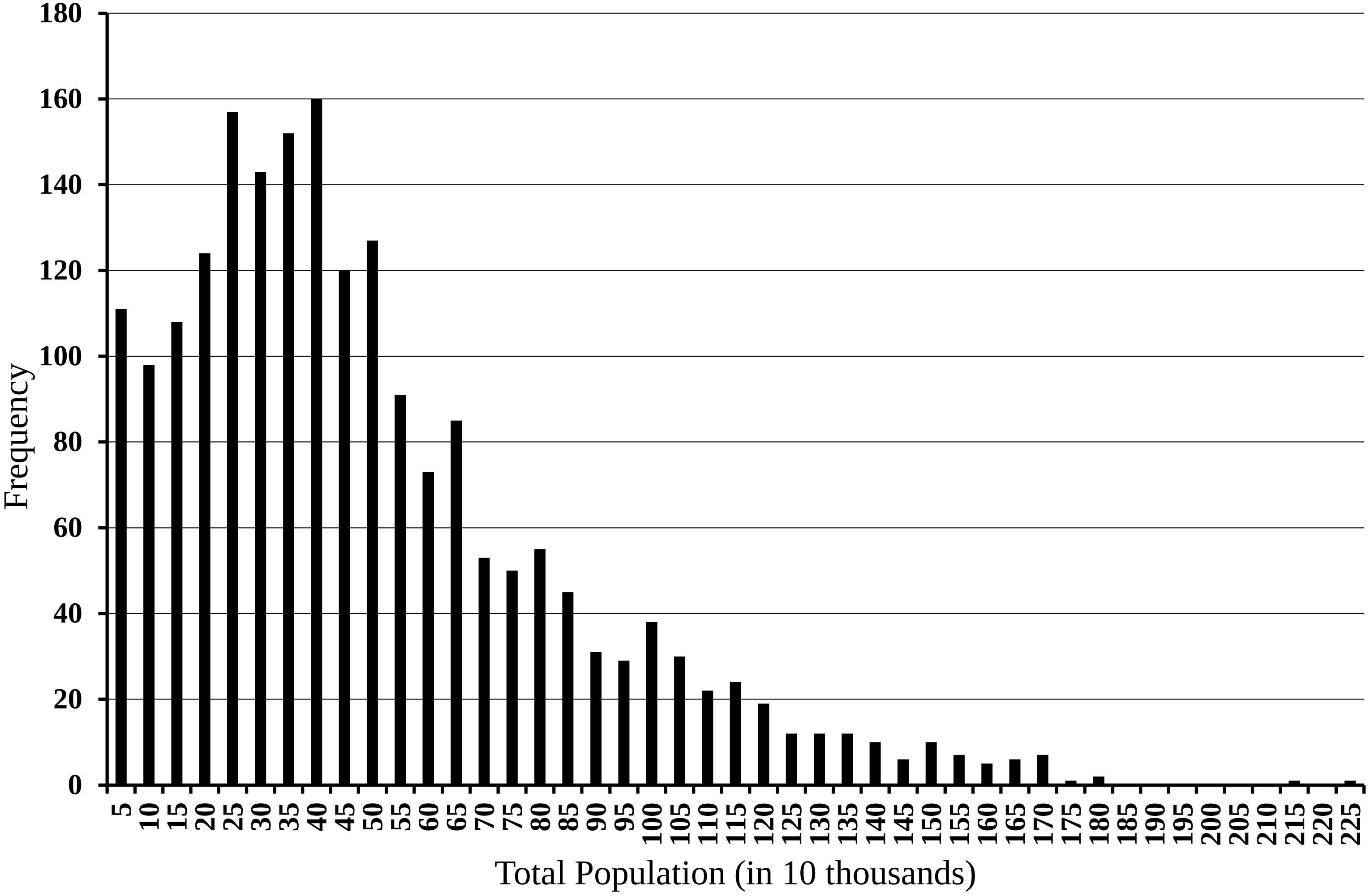

Figure 2. Histogram for “Pop”

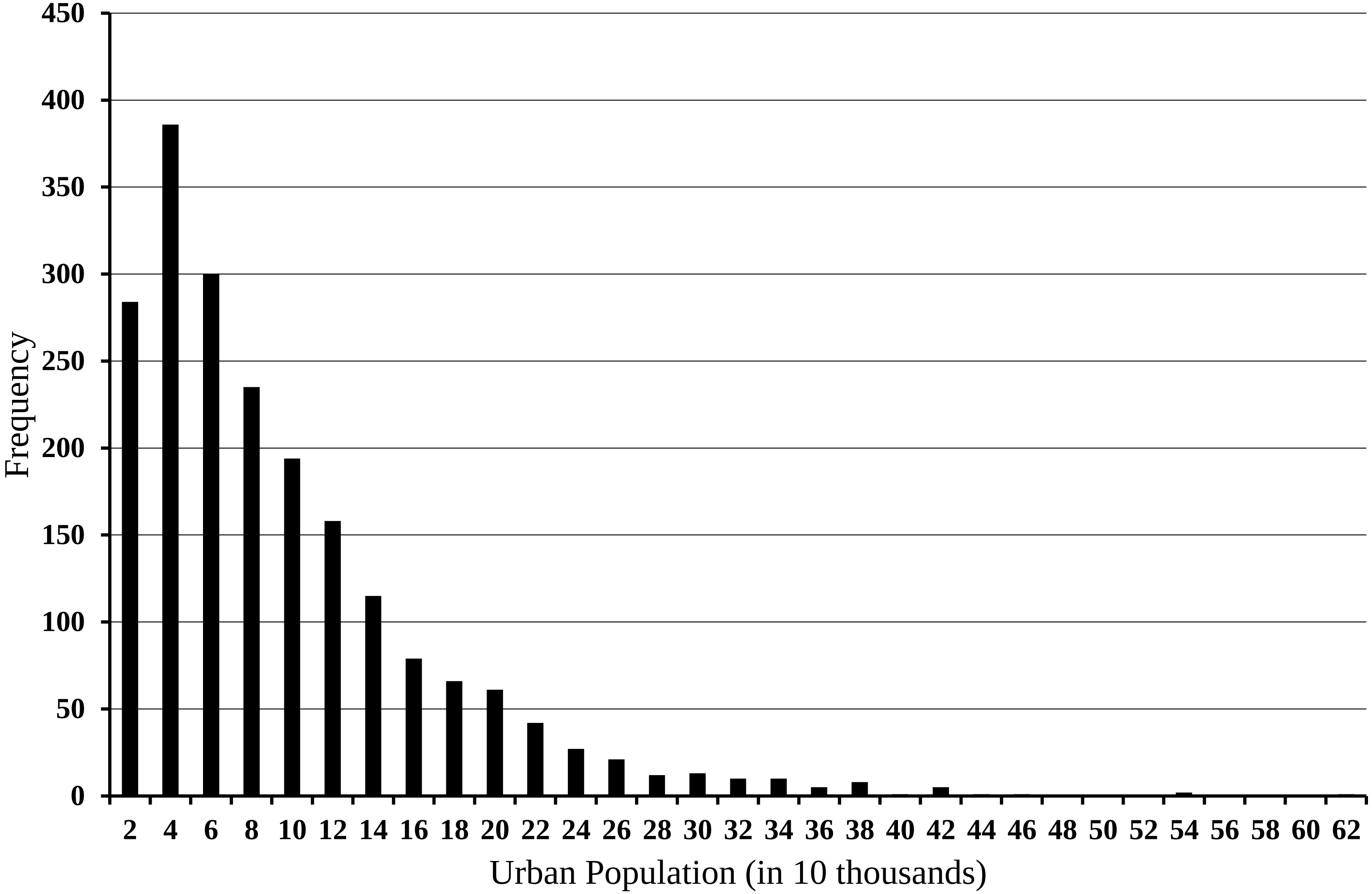

Figure 3. Histogram for “Upop”

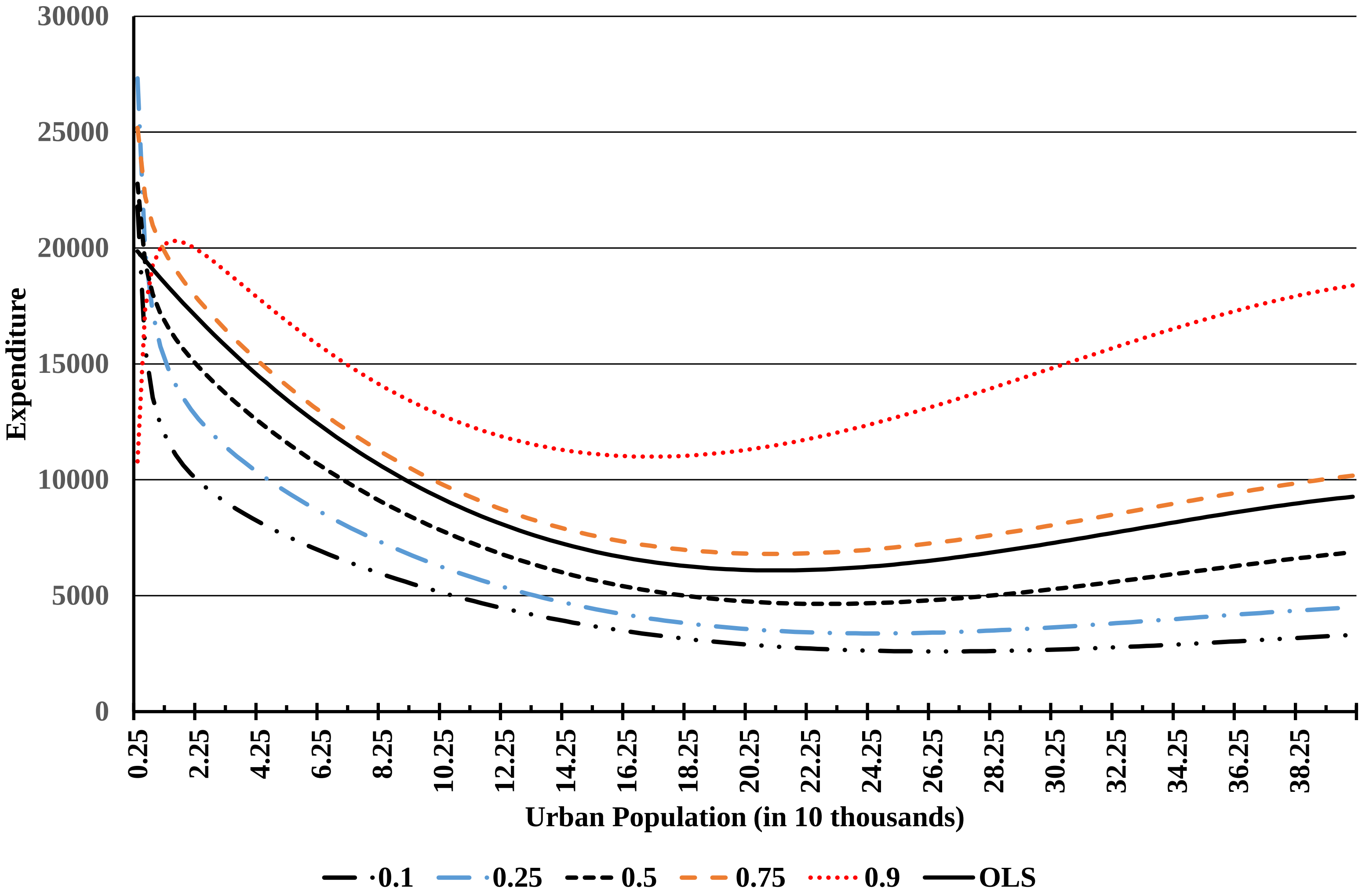

Figure 4. Urban population and local government expenditure

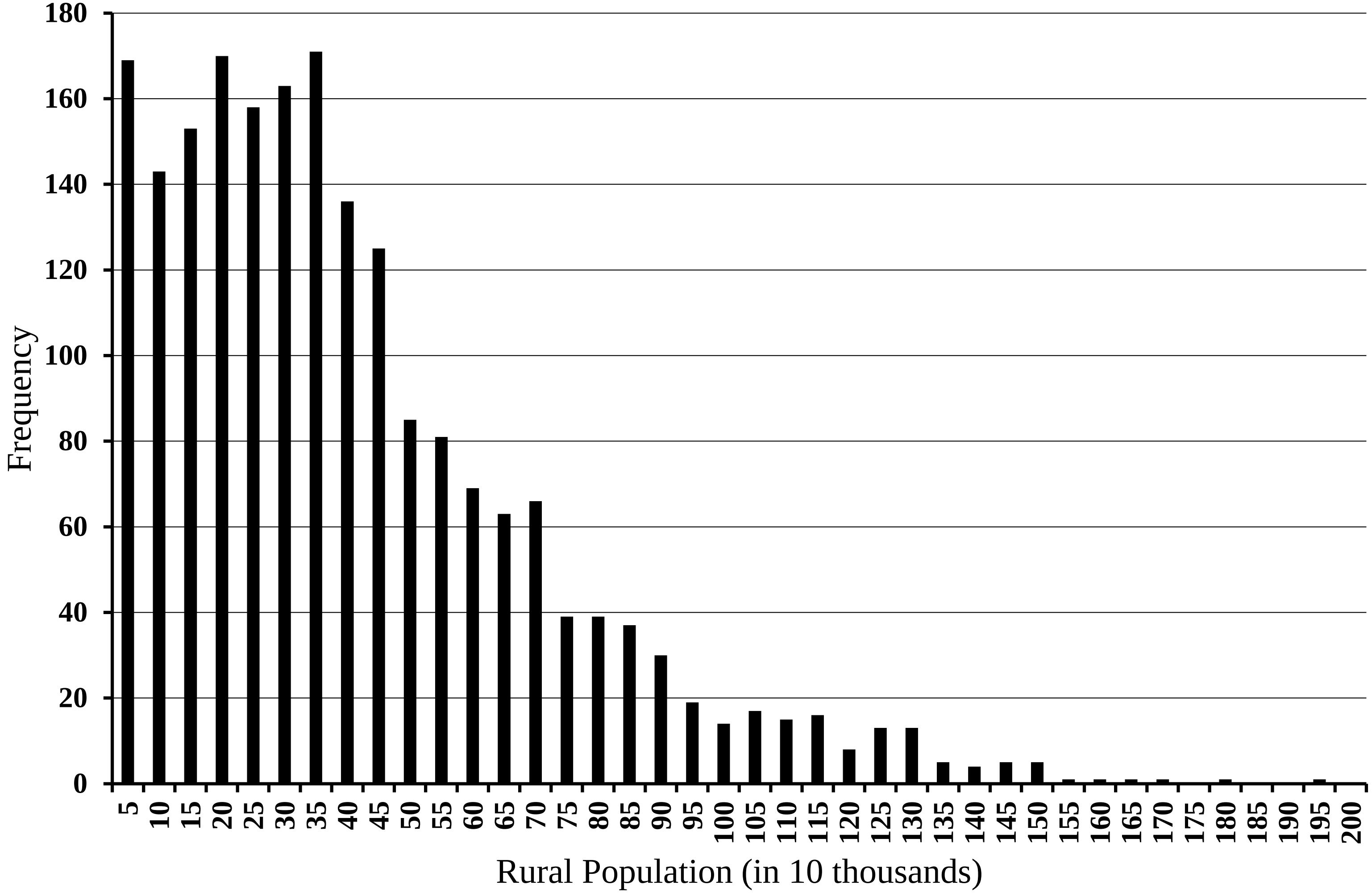

Figure 5. Histogram for “Apop”

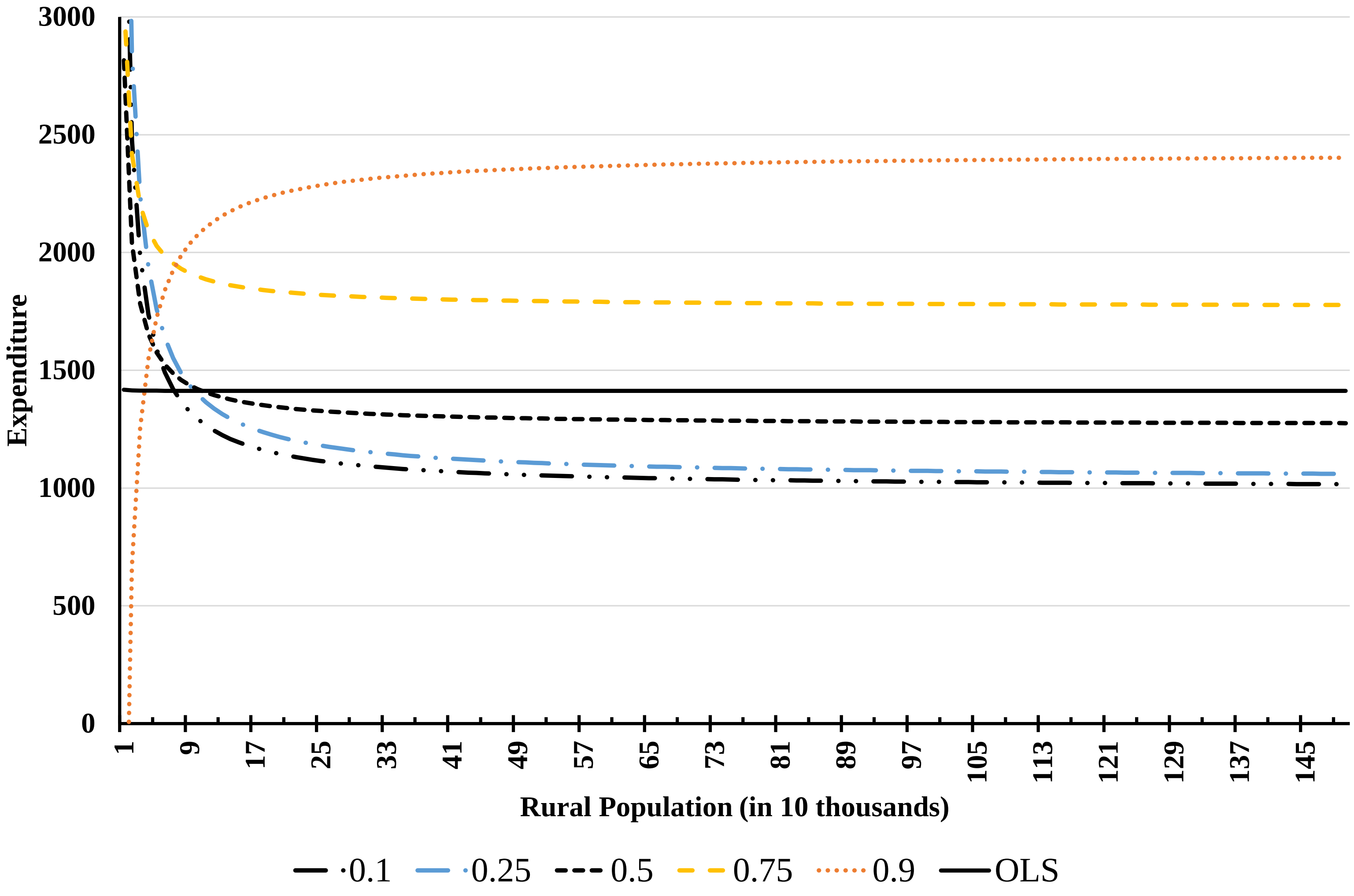

Figure 6. Rural population and local government expenditure

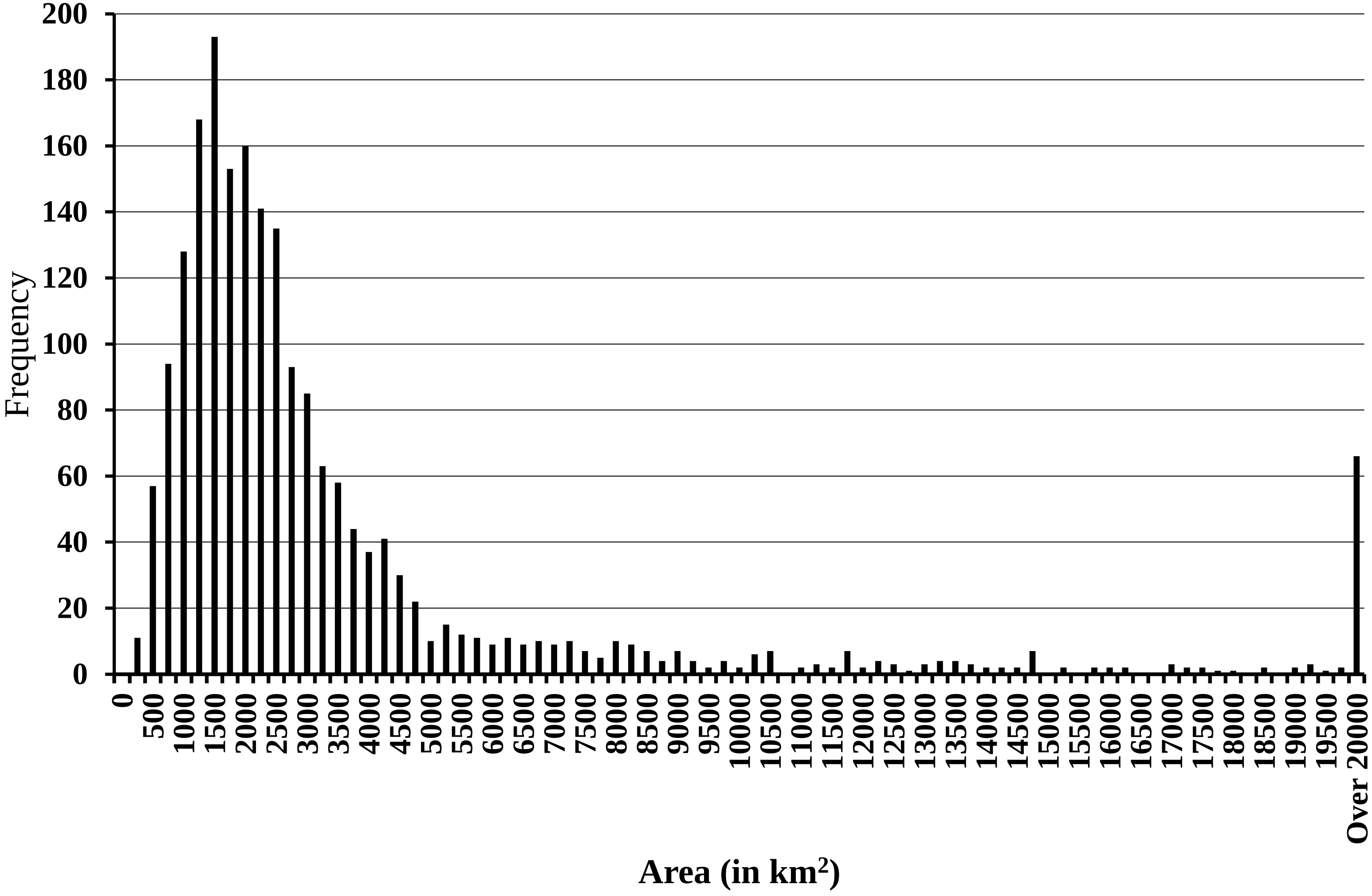

Figure 7. Histogram for “Area”

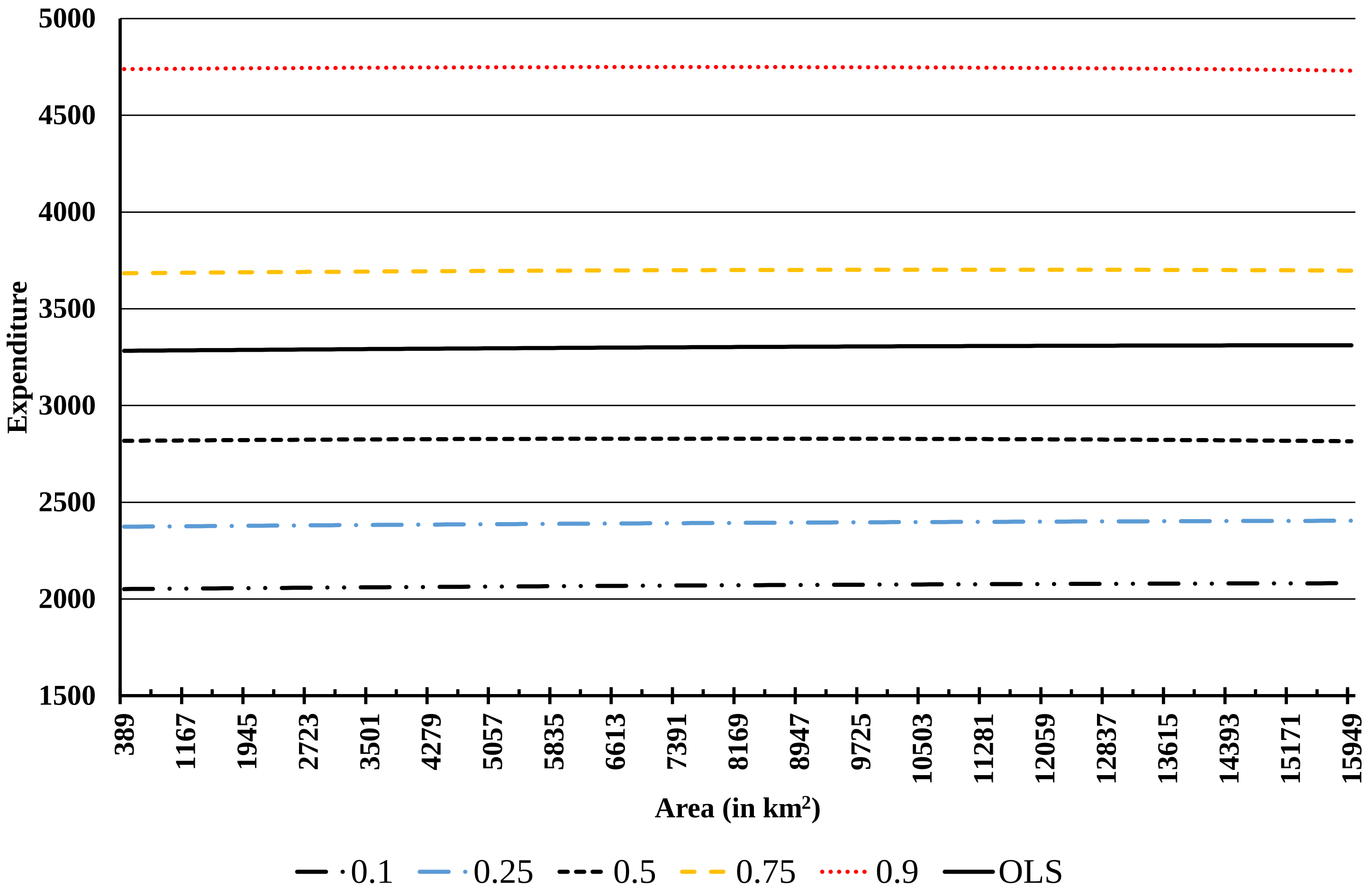

Figure 8. Area and local government expenditure