

CHAPTER 4. METHODOLOGY

In previous empirical studies, this study can obtain that the explanatory variables including the economic development factor, the openness and institution factors. Moreover, several studies express the geography factor and specific time effect would influence tax effort, too. Therefore, the study adopts the two-way fixed effects model.²⁵ In this chapter, this study will interpret the fixed effects model. Subsequently, this study expresses the empirical results of this model in order to understand the impact of the fiscal decentralization on the tax effort.

4.1 Fixed Effect Model

This equation of the fixed effects model supposes that there are differences across individuals. Each ϕ_i is regarded as an unknown parameter to be estimated. Let Y_i and X_i be the T observations for the i th unit, $J = (1 \ 1 \ \dots \ 1)'$ be a $T \times 1$ column of ones, and let ε_i be the associated $T \times 1$ vector of disturbances. Then,

$$Y_i = X_i\beta + J\phi_i + \varepsilon_i \quad (4-1)$$

$$Y_i = \begin{bmatrix} Y_{i1} \\ Y_{i2} \\ \vdots \\ Y_{iT} \end{bmatrix} \quad X_i = \begin{bmatrix} X_{1i1} & X_{2i1} & \cdots & X_{Ki1} \\ X_{1i2} & X_{2i2} & \cdots & X_{Ki2} \\ \vdots & \vdots & \vdots & \vdots \\ X_{1iT} & X_{2iT} & \cdots & X_{KiT} \end{bmatrix} \quad \varepsilon_i = \begin{bmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \\ \vdots \\ \varepsilon_{iT} \end{bmatrix}$$

Replace (4-1) with these terms to obtain following

²⁵ The methodology of this main study refer to Greene (2003)

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_N \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_N \end{bmatrix} \beta + \begin{bmatrix} J & 0 & \cdots & 0 \\ 0 & J & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & J \end{bmatrix} \begin{bmatrix} \phi_1 \\ \phi_2 \\ \vdots \\ \phi_N \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_N \end{bmatrix} \quad (4-2)$$

Or

$$Y = [d_1 \ d_2 \ \cdots \ d_N \ X] \begin{bmatrix} \phi \\ \beta \end{bmatrix} + \varepsilon \quad (4-3)$$

where d_i is a dummy variable indicating the i th unit. Let the $NT \times N$ matrix $D = [d_1 \ d_2 \ \cdots \ d_N]$. Then, assembling all NT rows obtains the following:

$$Y = X\beta + D\phi + \varepsilon \quad (4-4)$$

This model is usually referred to as the least squares dummy variable (LSDV) model. Moreover, the fixed effects model can be formulated as a pooled regression model.

The original formulation is

$$Y_{it} = \sum_{k=1}^K \beta_k X_{kit} + \phi_i + \varepsilon_{it} \quad (4-5)$$

And the group means

$$\bar{Y}_i = \frac{1}{T} \sum_{t=1}^T Y_{it} = \phi_i + \sum_{k=1}^K \beta_k \bar{X}_{ki} + \bar{\varepsilon}_i \quad (4-6)$$

Deviations from the group means can be expressed in (4-7) by (4-5) subtracting (4-6).

$$Y_{it} - \bar{Y}_i = \sum_{k=1}^K \beta_k (X_{kit} - \bar{X}_{ki}) + (\varepsilon_{it} - \bar{\varepsilon}_i) \quad (4-7)$$

Consider then the matrices of the sums of squares and cross products that would be used in each case, where this study only focuses on the estimation of β . The

moments would accumulate the variation from the overall means, \bar{Y} and \bar{X} , and this study could obtain the total sums of the squares and cross products in (4-8).

$$S_{xx}^{total} = \sum_{i=1}^N \sum_{t=1}^T (X_{it} - \bar{X})(X_{it} - \bar{X})' \quad S_{xy}^{total} = \sum_{i=1}^N \sum_{t=1}^T (X_{it} - \bar{X})(Y_{it} - \bar{Y})' \quad (4-8)$$

The moment matrices are within-group sums of the squares and cross products expressed in (4-9).

$$S_{xx}^{within} = \sum_{i=1}^N \sum_{t=1}^T (X_{it} - \bar{X}_i)(X_{it} - \bar{X}_i)' \quad S_{xy}^{within} = \sum_{i=1}^N \sum_{t=1}^T (X_{it} - \bar{X}_i)(Y_{it} - \bar{Y}_i)' \quad (4-9)$$

The moment matrices are the between-groups sums of the squares and cross products. That is the variation of the group means from the overall means, expressed in (4-10).

$$S_{xx}^{between} = \sum_{i=1}^N T(\bar{X}_i - \bar{X})(\bar{X}_i - \bar{X})' \quad S_{xy}^{between} = \sum_{i=1}^N T(\bar{X}_i - \bar{X})(\bar{Y}_i - \bar{Y})' \quad (4-10)$$

Moreover, (4-8) is easy to understand and proven.

$$S_{xx}^{total} = S_{xx}^{within} + S_{xx}^{between} \quad S_{xy}^{total} = S_{xy}^{within} + S_{xy}^{between} \quad (4-11)$$

Thus, there are three possible least squares ways to estimate β . Three of the least squares estimators β separately are obtained by total, within-groups and between-groups means. Their estimations are as follows:

$$\hat{\beta}^{total} = [S_{xx}^{total}]^{-1} S_{xy}^{total} = [S_{xx}^{within} + S_{xx}^{between}]^{-1} [S_{xy}^{within} + S_{xy}^{between}] \quad (4-12)$$

$$\hat{\beta}^{within} = [S_{xx}^{within}]^{-1} S_{xy}^{within} \quad (4-13)$$

$$\hat{\beta}^{between} = [S_{xx}^{between}]^{-1} S_{xy}^{between} \quad (4-14)$$

Furthermore, the least squares estimator can be combined by a matrix weighted

average of the within- and between-groups estimators:

$$\hat{\beta}^{total} = F^{within} \hat{\beta}^{within} + F^{between} \hat{\beta}^{between} \quad (4-15)$$

Where

$$F^{within} = [S_{xx}^{within} + S_{xx}^{between}]^{-1} S_{xx}^{within} = I - F^{between} \quad (4-16)$$

In the following, this study will introduce a two-way fixed effect model. The least squares dummy variable approach can be extended to include a time-specific effect. One method to formulate the extended model is simply to add the time effect, as (4-17).

$$Y_{it} = \sum_{k=1}^K \beta_k X_{kit} + \phi_i + \varphi_t + \varepsilon_{it} \quad (4-17)$$

There are T time effects. The T interpretations of time effect should be estimated, but there would be collinearity. It cannot estimate all intercepts under the situation. Therefore, some restrictions are required in order to avoid collinearity. One of the time effects must be dropped and the formulation is:

$$Y_{it} = \sum_{k=1}^K \beta_k X_{kit} + \beta_0 + \phi_i + \varphi_t + \varepsilon_{it} \quad (4-18)$$

$$\text{Subject to } \sum_i \phi_i = \sum_t \varphi_t = 0$$

The estimations of the coefficients are obtained by (4-19).

$$Y_{it}^* = Y_{it} - \bar{Y}_i - \bar{Y}_t + \bar{Y} \quad X_{it}^* = X_{it} - \bar{X}_i - \bar{X}_t + \bar{X} \quad (4-19)$$

Where the period-specific and overall means are

$$\bar{Y}_{.t} = \frac{1}{N} \sum_{i=1}^N Y_{it} \quad \bar{Y} = \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T Y_{it} \quad \bar{X}_{.t} = \frac{1}{N} \sum_{i=1}^N X_{it} \quad \bar{X} = \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T X_{it}$$

Hence, (4-19) could be expressed by (4-20).

$$Y^*_{it} = \sum_{k=1}^K \beta_k X^*_{kit} + \varepsilon_{it} \quad (4-20)$$

The overall constant and the dummy variable coefficients can then be estimated as follows:

$$\hat{\beta}_0 = \bar{Y} - \bar{X}'\hat{\beta} \quad (4-21)$$

$$\hat{\phi}_i = (\bar{Y}_i - \bar{Y}) - \sum_{k=1}^K \hat{\beta}_k (\bar{X}_i - \bar{X}) \quad i = 1 \dots N \quad (4-22)$$

$$\hat{\phi}_t = (\bar{Y}_t - \bar{Y}) - \sum_{k=1}^K \hat{\beta}_k (\bar{X}_t - \bar{X}) \quad t = 1 \dots T \quad (4-23)$$

In consequence, it can use the hypothesis that all individual effects are equal to test whether the fixed effects model is correctly used. If all the coefficients of the individual effects are equal, the classic linear regression is more suitable than the fixed effects model and the test result will be “do not reject null hypothesis.” Contrarily, if all the coefficients of the individual effects are not equal, the classic linear regression is not more suitable than the fixed effects model and the test result will be “reject null hypothesis.”

$$H_0 : \phi_1 = \phi_2 \dots = \phi_N$$

$$H_1 : \textit{otherwise}$$

The standard F test for this is:

$$F(N-1, NT - N - K + 1) = \frac{(SSE_R - SSE_U)/(N-1)}{SSE_U/(NT - N - K + 1)} \quad (4-24)$$

where SSE_R and SSE_U are the separate sums of the square of the residual in the restricted and unrestricted models. The sum of squares of residuals in the restricted model means obtaining the sum of square of residue by the regression which all the

individual effects are equal. The sum of the square of residuals in the unrestricted model means obtaining the sum of the square of the residual.

4.2 Empirical Model

In order to explore the role of fiscal decentralization in the tax effort of local governments, this study primarily collects all related variables from various years of the *China Statistical Yearbook*. However, the *Chongqing Statistical Yearbook*,²⁶ *Sichuan Statistical Yearbook*, *Tibet Statistical Yearbook*,²⁷ and the *Finance Yearbook of China* are also used to complement related variables if necessary. Due to the data limitations, the research period covered by this study is limited to the years 1996 to 2004. The data set used in this study is a panel data set of China's 31 provinces/regions for 1996-2004. The advantage of panel data is that, compared with time series or cross-sectional data, such data contains more information and observations. Due to the larger sample size, the use of panel data can increase the number of degrees of freedom and make the estimation more accurate. In addition, the use of panel data can enable more empirical models to be considered, such as the fixed-effect model and the random-effect model.

According to the literature, the local government's tax effort is a function of the degree of fiscal decentralization (*FD*), per capita GRP (*PCGRP*), the ratio of industrial output value to GRP (*IND*), and a region's share of total trade value to GRP (*TRADE*). Therefore, this study establishes a two-way fixed-effects model with regional- and time-specific effects that can be presented as follows:

²⁶ Chongqing City is a municipality that has been detached from the Sichuan Province since 1997. Therefore its information prior to 1997 must be collected from the *Sichuan Statistical Yearbook* and *Chongqing Statistical Yearbook* in order to obtain a complete and true data set.

²⁷ The consumer price index in Tibet in 1995 and 1996 is not available in the *China Statistical Yearbook*, and therefore the *Tibet Statistical Yearbook* is used to complement it. In addition, Tibet's population and GDP for the early part of the reform period are only reported in the *Tibet Statistical Yearbook*.

$$TE_{i,t} = \alpha_0 + \alpha_i + \theta_t + \beta_1 FD_{i,t-1} + \beta_2 PCGRP_{i,t-1} + \beta_3 IND_{i,t-1} + \beta_4 TRADE_{i,t-1} + \varepsilon_{i,t} \quad (4-25)$$

In equation (4-25), α_i represents the i^{th} region's regional-specific effect and θ_t represents the t^{th} year's time-specific effect, where $i=1, 2, \dots, 31$ and $t=1996, 1997, \dots, 2004$. $TE_{i,t}$ denotes the degree of tax effort of the i^{th} region in year t . As mentioned earlier, there are four types of tax effort indices including $TE-PI$, $TE-GRP$, $TE-TTR$, and $TE-RTS/R$ that are used in this study. Therefore, four empirical models each with four tax effort indices are estimated in this study. In addition, $\varepsilon_{i,t}$ represents the error term with zero mean and variance σ^2 .²⁸ It is worth noting that all dependent variables are lagged one year in order to avoid any potential endogeneity problems between any dependent and independent variables. In order to eliminate any fluctuations in prices, all value variables in this study are adjusted by the CPI deflator (base year=1995). The definitions, descriptive statistics, and expected signs of all of the variables are listed and described in Table 8 and analyzed in the paragraphs below.

$FD_{i,t}$ denotes the degree of fiscal decentralization of the i^{th} region in year t and is measured by equation (3-5). As indicated by Bird, Martinez-Vazquez and Torgler (2004), the higher level of fiscal decentralization induces the local government to collect more revenue in order to avoid registering a deficit budget. This study expects the influence of fiscal decentralization on the tax effort to be positive.

²⁸ It is normally distributed and also satisfies the general assumption of an independent and identical distribution (iid).

Table 8: Descriptive Statistics and Definitions of Variables

Variables	Definitions	Mean (S.D.)	Expected Sign
<i>TE-PI</i>	The tax effort measured by provincial per capita income as tax capacity. (%)	0.127 (0.062)	
<i>TE-GRP</i>	The tax effort measured by provincial GRP as tax capacity. (%)	0.057 (0.024)	
<i>TE-TTR</i>	The tax effort measured by provincial total taxable resources as tax capacity. (%)	0.007 (0.005)	
<i>TE-RTS/R</i>	The tax effort measured by provincial prediction of province revenue under RTS/R as tax capacity. (%)	0.659 (0.27)	
<i>FD</i>	The degree of fiscal decentralization defined as the ratio of the local government's total revenue reducing the amount paid to the central government to the total revenue which is the local government's total revenue reducing the payment to the central government and adding the transformation from the central government. (%)	48.70 (14.64)	+
<i>PCGRP</i>	Per Capita GRP. (10 thousand RMB)	0.697 (0.47)	?
<i>IND</i>	The ratio of provincial industry value of output to GRP. (%)	0.36 (9.23×10^{-2})	+
<i>TRADE</i>	A region's share of total trade value to GRP. (%)	0.289 (0.414)	+

Source: *China Statistical Yearbook, Chongqing Statistical Yearbook, Sichuan Statistical Yearbook, Tibet Statistical Yearbook and Finance Yearbook of China*

$PCGRP_{i,t}$ represents region i 's per capita GRP in year t . Per capita GRP is always considered to be an important variable that influences the tax effort in many studies (e.g., Alm, Martinez-Vazquez and Schneider, 2003; Piancastelli, 2001; Shin, 1969; Lotz and Morss, 1967). The influence of per capita GRP could be either positive or negative. If per capita GRP is higher, this implies that the government finds it easier to collect tax because the residents have sufficient revenue. Therefore, the influence of per capita GRP could be positive. However, since the higher per capita GRP also represents the higher level of development, it provides no incentive to local

governments to work hard to collect taxes,²⁹ and thus the influence of per capita GRP on the tax effort might be negative. Hence, this study expects the sign of $PCGDP$ to be uncertain.

$IND_{i,t}$ represents the ratio of region i 's industry output value to its GRP in year t . The higher industry share is important because industrialization can generate large taxable surpluses. Moreover, due to the industry enterprises as typically being easier to tax because business owners regularly keep better books and records, the industrialization exhibits a positive relationship with tax effort. Hence, this study expects the industry share of GRP to positively affect tax effort.

$TRADE_{i,t}$ represents the share of the total trade value to the GRP of the i^{th} region in year t . In the literature, the share of the total trade value is regarded as the level of openness. Since the tariff duties are more easily collected than income tax, the local government might have a higher tax effort if the region has a higher degree of openness. Therefore, this study expects that the share of the trade value will positively affect the tax effort.

²⁹ This is because they usually have sufficient revenue to deal with their public expenditure.