Tax Efficiency and Financial Effectiveness of Local Governments in Taiwan: A Two-Stage Empirical Analysis

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Abstract

This study applies a two-stage data envelopment analysis method to measure the efficiency of local governments in Taiwan from 2010 to 2015 and proposes a vector auto regression model that uses an impulse response function to measure the impulse responses of efficiency towards government policies in the two stages. The results are as follows. Average tax efficiency and financial effectiveness decreased annually. The overall government efficiency of municipalities was better than that of non-municipalities. The gaps (slack values) between the tax efficiency and financial effectiveness of the majority of governments were negative, showing that their tax efficiency was inferior to their financial effectiveness. In addition, the distance between the tax efficiency and financial effectiveness of non-municipal governments expanded. Impacted by the announcement of government policies to adjust the present value of land, tax efficiency was found to be significantly negative, while financial effectiveness presented a significantly positive response.

Keywords: Data envelopment analysis, efficiency, local government

I Introduction

The focus of government management improvement has shifted towards the evaluation of the performance of local governments (Palmer, 1993). When more than one decision-making unit (DMU) is present, data envelopment analysis (DEA) is usually adopted to measure the relative efficiency of the DMU and calculate the benchmarking index (Liu et al., 2013a, 2013b; Lim & Zhu, 2016). The application of the DEA method, in various types of research, has been rapidly expanding; however, one-stage DEA has been criticized for creating “black boxes” during production processes and ignoring their intermediate structure (Du et al., 2011). Balaguer-Coll et al. (2007) were the first to adopt a standard two-stage DEA model (Cook, Liang, & Zhu, 2010) to measure the efficiency of local governments. Subsequent studies have also adopted the two-stage DEA approach to assess the efficiency of tax authorities and tax efficiency (Thirtle et al., 2000; Annick, 2002; Katharaki & Tsakas, 2010; González & Rubio, 2013; Førsund et al., 2015). Practically, “efficiency” is defined as “doing the right thing” and “effectiveness” is defined as “doing things right.” Therefore, empirical research usually quantifies performance measurement into efficiency and effectiveness. Against this background, this study adopts a two-stage DEA approach to measure the efficiency and effectiveness of government performance to analyze the inputs, intermediate products, and outputs of the local government more specifically and avoid the “black box” issues caused by the traditional DEA model. A common stream of financial revenue for local governments is tax revenue. Local governments usually have the authority to develop and modify the local tax system. In addition, housing tax and land tax, which are both property taxes, are regarded as stable sources of income for local governments. Stine (2003) studied 66 counties in Pennsylvania and found that the repeal of personal property tax had a significant impact on the real estate market.

This study proposed a vector autoregression (VAR) model that considered all economic variables as dependent variables to analyze the impulse response following changes in tax policies. This approach effectively resolves the shortcomings of the traditional regression models that require the identification of the relationship between the independent and dependent variables.

The present study offers the following contributions. Firstly, a two-stage DEA model is introduced, allowing the simultaneous analysis of both the efficiency and the effectiveness of local governments in Taiwan. Secondly, the efficiency and effectiveness of governments of municipalities and non-municipalities are examined individually to identify the benchmarks of the DMUs for each government group. Thirdly, an impulse response function is adopted to measure the response of the efficiency and effectiveness of local governments following the announcement of policies that adjust the present value of land (PVL), the results of which could be used as reference for local governmental policymakers. The remaining sections of this paper are organized as follows. Section 2 reviews past studies that have used DEA analysis to analyze government efficiency; Section 3 introduces the research design; Section 4 presents the empirical results; and Section 5 concludes.

2 Related Literature

Efficiency and effectiveness are also important factors in the performance evaluation of public sectors (Guo et al., 2016). Local governments of developed countries are undertaking rapid reforms to improve their efficiency and effectiveness (Kloot & Martin, 2000). Studies measuring governments' efficiency and effectiveness have differed substantially from their research goals to their conclusions (Andrews & Entwistle, 2010; Andrews & Van de Walle, 2013a, 2013b; Khilji & Roberts, 2013; Castro et al., 2014; Mbaya et al., 2014; Waller & Genius, 2015; Guo et al., 2016). DEA is usually adopted by scholars in performance assessment research, including integrated DEA models to jointly evaluate efficiency and effectiveness (Chiou & Yen, 2007; Finocchiaro et al., 2011; Chiou et al., 2010; Tavassoli et al., 2014; Azadi et al., 2015).

Although DEA has been widely introduced and an increase in the number of relevant studies has been noted, the application process tends to overlook internal performance. For example, Tsolas (2011, 2012) failed to handle the intermediate products in a coordinated manner; therefore, the results only reflected the efficiency of the first and second stages individually, rather than the overall efficiency of the system. For that reason, some researchers have tried to decompose the entire system structure by developing a new network DEA technique to measure internal efficiency. Such a model has been applied to measure the efficiency of technologies with a network structure (Färe & Grosskopf, 2000). Considering the presence of intermediate products, Kao and Hwang (2008) constructed a relational two-stage DEA model, which connects the first and second stages. Compared with the standard DEA models used by past research, the relational two-stage DEA model is more reliable; in addition to measuring the efficiency of the entire production system, it can also measure the efficiency of each stage. Kao and Hwang (2014) suggested that the utilization of network DEA could decompose a large-scale operation process into sub-processes so that practical problems could be determined. The empirical results confirmed that their proposed model can produce more meaningful results than the one-stage DEA model. Practical cases in which the two-stage structure was applied have formed the basis of studies of network DEA. For example, Cook et al. (2010) found that the two-stage DEA approach has been developed to investigate efficiency and performance in a variety of fields.

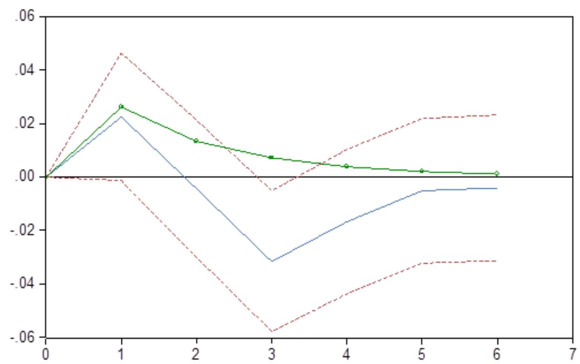
Stine (2003) empirically examined the impact of the repeal of personal property tax on real estate tax income, the growth of real estate tax, and other forms of tax income among 66 counties and found that the repeal policy led to higher growth and greater variability of real estate taxes. Traditional regression models tend to use structural equations to examine the influence of independent variables on dependent variables and consider the dependent variable to be an endogenous variable and the independent variable to be an exogenous variable. One of the main issues of traditional regression models lies in that researchers are required to subjectively assume the relationship between the independent and dependent variables before the analysis, resulting in inconsistencies between the hypotheses and empirical results. Moreover, when the model involves multiple variables, it is difficult for researchers to identify the independent and dependent variables, making empirical study even more challenging. Kapelko et al. (2015) introduced the impulse response method to study panel data on the meat processing industry in Spain and found no prior causal relationship between investment spikes; they also showed that average dynamic productivity declined during the period. The present study employs the same impulse response method to explore the responses of local governments' tax efficiency and financial effectiveness following the announcement of policies related to changes in the PVL.

3 Research Design

3.1 Two-Stage Production Process

Hu and Liu (2016) evaluated the performance of the construction industry in Australia, using a two-stage DEA approach. The first stage measured profitability efficiency, by introducing labor costs and capital as the inputs as well as gross value added and carbon dioxide emissions as the outputs of the model. In the second stage, only gross value added was introduced as the input and the gross operating surplus and mixed income were set as outputs. Many studies have also adopted a similar approach, where the outputs of the first stage were not fully included as the inputs of the second stage (Ahmad & Ma′in, 2014; Mohammad & Noordin, 2016). In this study, the inputs of the first stage were the labor costs, operating expenses, and equipment and investment costs (Hunter & Nelson, 1996) of the tax authorities for both county and city governments. The outputs were the number of investigated tax evasion cases, number of tax evasion cases closed (Malanga, 1986), and self-raised tax revenues (Thirtle et al., 2000). In the second stage, self-raised tax revenues were introduced as an input alongside all the public revenue streams of local governments (four items); and the outputs were defined as all public expenditure (four items). The data were extracted from the Audited Annual Results of Municipalities and Counties of the Republic of China between 2010 and 2015, published on the official websites of the Ministry of Finance and the National Audit Office Local Accounts. The assessment framework of the present study is presented in Figure 1 and the variables and corresponding definitions are shown in Table 1.

Fig. 1 The role of the local governments in Taiwan’s assessment framework



Response to Cholesky One S.D. Innovations 95% Marginal confidence bands of first stage to DUMMY

----------- Estimation at a 95% Confidence Interval

Estimated Value

Table 1 Variables and Definitions

	Variable	Definition
Input	Labor costs	Staff costs required by tax authorities engaged in tax collection work
	Operating expenses	General expense required by tax authorities engaged in tax collection work
	Equipment and investment costs	Capital costs required by tax authorities engaged in tax collection work
Output	Number of investigated tax evasion cases	Number of illegal tax evasion cases investigated by tax authorities in the last and contemporary period
	Number of tax evasion cases closed	Number of self-paid cases, number of court order payment cases, and number of cases transferred in the current period
Input/ Output	Self-raised tax revenues	For annual final accounts of national audit office, self-raised tax revenues includes land-value tax, land-value increment tax, house tax, vehicle license tax, deed tax, stamp tax and amusement tax, etc. (self-financing resources refer to the sum of self-raised tax revenues and other revenues)
Input	Other revenues	Annual final accounts of national audit office, other revenues including construction benefit fee, registration fee and fine, trust administration, property, operating surplus and business, donation and gift, other revenues, debts, etc.
	Co-ordination of tax revenues	According to the Regulations for the Allocation of Centrally Funded Tax Revenues in Taiwan, allotments are distributed to the local government. (non-self-financing resources refer to the sum of co-ordination of tax revenues and subsidy and assistance revenues)
	Subsidy and assistance revenues	Annual final accounts of national audit office subtracted by self-raised tax revenues, other revenues, and co-ordination of tax revenues.
Output	Education science and cultural expenditures	Expenditures of education, culture, etc. in the annual final accounts of national audit office
	Economic development expenditures	Expenditures of agriculture, industry, transportation, etc. in the annual final accounts of national audit office
	Social welfare expenditures	Expenditures of social insurance, social assistance, welfare services, national employment, medical care, etc. in the annual final accounts of national audit office
	Other expenses	In the annual final accounts of national audit office, other expenses includes general government programs (political power exercise, and administrative, civil affairs and financial affairs), community development and environmental protection (community development, environmental protection), retirement and pension (pays for retirement and pension), police affairs, debts (debt interests), other expenditures (second budget reserve, other expenditures), etc. (annual final accounts subtracted by education science and cultural expenditures, economic development expenditures, and social welfare expenditures)

Remark: According to the Regulations for Allocation of Centrally-Funded Tax Revenues issued by the Ministry of Finance, the sources of the centrally-funded tax revenues include income tax, business tax, commodity tax, and land value increment tax (from http://law.moj.gov.tw/LawClass/LawAll.aspx?PCode=G0320020).

3.2 Data Collection

This study employed data from 20 counties and cities in Taiwan between 2010 and 2015 as the DMU. All county and city governments had common organizational goals and core values, and followed the same legal norms, which is in line with the homogeneity standard required for implementing identical tasks. This is in accordance with Farrell (1957), who pointed out that all DMUs in a DEA evaluation should be homogeneous. Next, based on the similarities in nature, the governments were divided into municipality and non-municipality groups, and the benchmarks for the DMUs were identified for each group. Because of a lack of statistical data from local tax bureaus as well as the small size of Kinmen County and Lienchiang County, they were not included in this study. Table 2 presents the descriptive statistics of the data.

Table 2 Descriptive statistics of inputs and outputs

	Unit	Max	Min	Average	Stand Error
Labor costs	Million dollars	756	51	257	195
Operating Expenses	Million dollars	293	13	96	78
Equipment and investment costs	Million dollars	64	0	12	11
Number of investigated tax evasion cases	cases	42094	66	5861	6401
Number of tax evasion cases closed	cases	69674	81	10256	12076
Self-raised tax revenues	Million dollars	85947	200	14775	19999
Other revenues	Million dollars	52584	456	6585	9447
Co-ordination of tax revenues	Million dollars	38126	1,300	9492	9459
Subsidy and Assistance revenues	Million dollars	45800	4200	15384	8976
Education science and cultural expenditures	Million dollars	64688	1800	16528	16425
Economic development expenditures	Million dollars	28489	1159	7395	6725
Social welfare expenditures	Million dollars	44720	900	7626	9862
Other expenses	Million dollars	58979	3000	16448	15280

Golany and Roll (1989) claimed that DEA requires the empirical data to be greater than 0 and suggested as a rule of thumb that the number of DMUs to be assessed should be at least twice the total input and output items in each stage. This study included 20 DMUs, with six input and output items in the first stage and eight in the second stage. Therefore, the number of DMUs satisfied the aforementioned requirements. In addition, Golany and Roll (1989) suggested that the input and output items of the model should be positively correlated. The Pearson correlation coefficients of the input and output items were positive, indicating that the data were suitable for the DEA model (Tables 3 and 4).

Table 3 First-stage Pearson analysis of inputs and outputs

	Labor costs	Operating expenses	Equipment and investment costs	Number of investigated tax evasion cases	Number of tax evasion cases closed	Self-raised tax revenues
Labor costs	1.000					
Operating expenses	0.821	1.000				
Equipment and investment costs	0.630	0.658	1.000			
Number of investigated tax evasion cases	0.565	0.770	0.456	1.000		
Number of tax evasion cases closed	0.679	0.851	0.594	0.732	1.000	
Self-raised tax revenues	0.947	0.761	0.536	0.491	0.638	1.000

Table 4 Second-stage Pearson analysis of inputs and outputs

	Self-raised tax revenues	Other revenues	Co-ordination of tax revenues	Subsidy and assistance revenues	Education science and cultural expenditures	Economic development expenditures	Social welfare expenditures	Other expenses
Self-raised tax revenues	1.000							
Other revenues	0.953	1.000						
Co-ordination of tax revenues	0.962	0.934	1.000					
Subsidy and assistance revenues	0.715	0.678	0.772	1.000				
Education science and cultural expenditures	0.966	0.939	0.981	0.807	1.000			
Economic development expenditures	0.904	0.827	0.892	0.813	0.885	1.000		
Social welfare expenditures	0.927	0.927	0.939	0.785	0.949	0.828	1.000	
Other expenses	0.937	0.896	0.941	0.860	0.949	0.925	0.909	1.000

3.3 BCC Model

Based on the efficiency model developed by Farrell (1957), Charnes, Cooper, and Rhodes (1978) put forward an efficiency model that used the output/input ratio as a measurement. The newly developed model could be used to identify less efficient DMUs and provide directions for improvement. In addition, since the production function of the model is not required to be set in advance, the function parameters do not require estimation, and the weights are not defined manually, the model has tremendous variability as a non-stochastic frontier approach that uses convex functions. The model was later named DEA. The Charnes, Cooper, and Rhodes (CCR) model assumes constant return to scale (CRS), which can measure the efficient frontier of technical efficiency. The CCR model can be expressed with a linear programming formula as follows:

$$\begin{aligned} &\min_{\theta,\lambda} \theta \\ &\textit{subject to} \quad -y_i + Y\lambda \geq 0 \\ &\qquad\qquad \theta_{x_i} - X\lambda \geq 0 \\ &\qquad\qquad \lambda \geq 0 \end{aligned} \tag{1}$$

where θ is the estimated technical efficiency of each DMU, which satisfies the condition $\theta \leq 1$. $\theta = 1$ indicates that the DMU is above the efficient frontier, whereas $\theta < 1$ means that the DMU is below the efficient frontier. When θ is between 0 and 1, there is a slack between the inputs and outputs. X represents the input matrix, Y represents the output matrix, and λ is a constant vector. For the ith DMU, ix (≥ 0) refers to the $N \times 1$ input vector of the ith DMU and iy (≥ 0) refers to the $M \times 1$ input vector of the ith DMU. Thereafter, Banker, Charnes, and Cooper (1984) removed the assumption of CRS and developed the BCC model that assumes variable return to scale. The model can be expressed as a linear programming formula as follows:

$$\begin{aligned} &\min_{\theta,\lambda} \theta \\ &subject\ to \quad -y_i + Y\lambda \ge 0 \\ &\qquad\qquad \theta_{x_i} - X\lambda \ge 0 \\ &\qquad\qquad N'\lambda = 1 \\ &\qquad\qquad \lambda \ge 0 \end{aligned} \tag{2}$$

Compared with the CCR model, the BCC model showed one more convex restriction, N ‘λ = 1, which can envelope the data points more closely. In this study, the BBC model was thus employed to establish the connections between the production activities in the two stages.

3.4 Impulse Response Model

Sims (1980) developed the VAR model, which considers all economic variables to be dependent variables to study the influence of each variable with its own lagged value as well as the lagged values of other variables. The VAR model is composed of a set of multiple variables and multiple regression equations. The dependent variables of each equation are expressed by their own lagged values and the lagged values of other variables. A general VAR model can be expressed as follows:

$$Y_t = \alpha + \sum \beta_i Y_{t-1\ m\ i} = 1 + \varepsilon_t \tag{3}$$

where Y_t is the n × 1 vector of the endogenous variables, Y_{t-1} is the n × 1 vector of the ith lag of Y_t, β_i is an $n \times n$ matrix, and ε_t is an n × 1 vector of the error terms in the first period, which can be considered to be the impulse and unexpected variances when used to analyze a time series.

The impulse response function directly measures the dynamic interaction between the variables. It can be used to estimate the stochastic error terms within one standard deviation change and describe the trajectory of the current and future values of the endogenous variables. Specifically, it can be used to estimate the responses of the endogenous variables of the VAR system within one unit of change of any single variable. Impulse response analysis therefore explores the responses of all variables of the model towards the change in any single variable (within one standard deviation) caused by the impact of an exogenous variable and produces the size and direction of the variation at the last interval. The general formula of an impulse response function is derived from that of the VAR. The general VAR formula is expressed as follows:

$$Y_t = \alpha + \sum B_i Y_{t-1} + \varepsilon_t \tag{4}$$

Based on the Wold Decomposition Theorem, Sims (1980) decomposed the aforementioned formula and transformed it into a moving average expression. Each variable in the transformed model can be expressed as a linear combination of the random impact items of the current and lagged periods. The processes can be expressed as follows:

$$Y_t - \sum B_i Y_{t-1} = \alpha + \varepsilon_t$$

$$(1 - \beta_1 L - \beta_2 L^2 - \cdots \beta_m L^m)\, Y_t = \alpha + \varepsilon_t$$

$$Y_t = (1 - \beta_1 L - \beta_2 L^2 - \cdots \beta_m L^m)^{-1} \alpha + (1 - \beta_1 L - \beta_2 L^2 - \cdots \beta_m L^m)^{-1} \varepsilon_t$$

$$Y_t = \alpha' + \sum c_i \varepsilon_{t-i} \tag{5}$$

where L is the lag operator, α' is the constant n × 1 vector, c_i is an $n \times n$ matrix, c_0 = I (unit matrix), and ε_t is the random shock of the n × 1 vector combination in the first period.

When random shocks are contemporaneously uncorrelated, the percentage of the forecast error variance decomposition can be calculated, and the relationships between the variables can thereby be determined. At this point, the combination of the random shock caused by the external shock on any variable of the model has only one solution. If the forecast error terms are contemporaneously correlated, then the Cholesky decomposition should be applied and a lower triangular matrix selected to eliminate contemporaneous correlations between the forecast error terms through an orthogonalization process. The process can be expressed as follows:

$$Y_t = \alpha' + \sum c_i F F^{-1} \varepsilon_{t-i} \tag{6}$$

where F is a non-singular matrix.

Let $D_i = c_i F$, $\eta_{t-i} = F^{-1} \varepsilon_{t-i}$. Hence, the above expression can be rewritten as

$$Y_t = \alpha' + \sum D_i \eta_{t-i} \tag{7}$$

where η_{t-i} is the non-autocorrelated and contemporaneously uncorrelated random impact items.

4. Results

4.1 Local Government Efficiency Analysis

As shown in Table 5, in the first stage, governments' overall tax efficiency reduced from 0.852 in 2010 to 0.785 in 2015; hence, the inefficiency value increased from 0.148 (1 - 0.852 = 0.148) to 0.215 (1 - 0.785 = 0.215). The average tax efficiency of municipalities increased from 0.836 in 2010 to 0.908 in 2015, while the average tax efficiency of non-municipalities decreased from 0.859 in 2010 to 0.732 in 2015.

In terms of the DMU, among the six municipality governments, the tax efficiency value of four governments reached 1.000 between 2010 and 2015, including Taipei City (five times), New Taipei City (four times), Taoyuan City (four times), and Taichung City (once). Among the 14 governments of the non-municipalities, the tax efficiency of five governments reached 1.000 between 2010 and 2015, including Hsinchu City (once), Nantou County (once), Pingtung County (once), Taitung County (twice), and Penghu County (three times). These results show the tax efficiency value reached 1.000 more often among municipal governments than non-municipal governments. The frequency of the tax efficiency of municipal and non-municipal governments exceeding 0.700 was 30 and 54, respectively. The tax efficiency of Taipei City and New Taipei City was higher than that of the other cities and counties, and these could be regarded as benchmark cities. In addition, the tax efficiency of six non-municipalities (Keelung City, Miaoli County, Changhua County, Yilan County, Chiayi County, and Pingtung County) was considerably lower than the other cities and counties (below 0.700 more than four times during the six years).

In the second stage, governments' overall financial effectiveness decreased from 0.994 in 2010 to 0.962 in 2015, while the inefficiency value increased from 0.006 (1 - 0.994 = 0.006) to 0.038 (1 - 0.962 = 0.038). Specifically, the average financial effectiveness of municipal governments dropped from 1.000 in 2010 to 0.983 in 2015 and that of non-municipal governments dropped from 0.991 in 2010 to 0.954 in 2015. The DMU analysis showed that the financial effectiveness of all six municipalities reached 1.000 during 2010 and 2015 (six times for Taipei City, six times for New Taipei City, three times for Taoyuan City, four times for Taichung City, four times for Tainan City, and five times for Kaohsiung City). The financial effectiveness of Taipei City and New Taipei City was better than that of the other counties and cities. The frequency of the financial effectiveness of the 14 non-municipalities reaching 1.000 was relatively low. In addition, the financial effectiveness of several counties dropped below 0.900 more than twice, including Yilan County (four times), Changhua County (twice), Nantou County (twice), and Hualian County (twice). The reasons for the low tax efficiency and financial effectiveness of non-municipal governments may be related to local industries. For example, in Yilan County and Changhua County, agriculture is the main industry. Developing the agriculture industry is challenging, which might in turn have resulted in low efficiency and effectiveness for these two county governments.

Table 5 Tax collection efficiency and financial effectiveness of the local governments in Taiwan

	Tax collection efficiency						Financial effectiveness					
	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015
Municipality												
Taipei City	1.000	0.956	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
New Taipei City	1.000	1.000	0.952	1.000	1.000	0.947	1.000	1.000	1.000	1.000	1.000	1.000
Taoyuan City	1.000	1.000	1.000	0.958	0.767	1.000	1.000	0.995	0.894	0.940	1.000	1.000
Taichung City	0.631	0.899	0.751	0.823	0.776	1.000	1.000	1.000	0.965	1.000	0.998	1.000
Tainan City	0.650	0.672	0.601	0.577	0.765	0.710	1.000	1.000	0.986	1.000	1.000	0.932
Kaohsiung City	0.736	0.633	0.758	0.775	0.824	0.793	1.000	1.000	1.000	1.000	1.000	0.965
Average of Municipalities	0.836	0.860	0.844	0.856	0.855	0.908	1.000	0.999	0.974	0.990	1.000	0.983
Non-Municipality												
Keelung City	0.890	0.652	0.680	0.682	0.645	0.617	1.000	0.943	0.940	0.897	0.947	0.928
Yilan County	0.670	0.886	0.788	0.867	0.686	0.677	1.000	0.846	0.885	0.844	0.936	0.853
Hsinchu County	0.754	0.860	0.843	0.834	0.789	0.792	1.000	1.000	1.000	0.958	1.000	0.960
Hsinchu City	1.000	0.945	0.963	0.980	0.949	0.970	1.000	0.994	0.994	0.922	0.958	1.000
Miaoli County	0.760	0.721	0.542	0.558	0.563	0.596	1.000	1.000	1.000	1.000	1.000	1.000
Changhua County	0.953	0.688	0.581	0.576	0.547	0.612	1.000	1.000	1.000	0.882	0.933	0.884
Nantou County	0.706	1.000	0.740	0.707	0.704	0.847	0.931	0.877	0.966	0.984	0.837	0.948
Yunlin County	0.942	0.690	0.665	0.613	0.533	0.501	1.000	1.000	0.922	0.975	0.969	0.978
Chiayi County	0.864	0.742	0.658	0.628	0.616	0.581	1.000	0.974	1.000	1.000	0.990	1.000
Chiayi City	0.994	0.787	0.731	0.718	0.765	0.884	1.000	1.000	1.000	0.969	0.995	1.000
Pingtung County	0.854	1.000	0.509	0.525	0.457	0.555	1.000	1.000	1.000	0.998	0.971	0.917
Hualien County	0.727	0.876	0.782	0.797	0.842	0.882	0.945	0.948	0.908	0.825	0.896	0.936
Taitung County	0.915	0.930	1.000	0.999	1.000	0.772	1.000	1.000	1.000	1.000	1.000	1.000
Penghu County	1.000	0.963	1.000	1.000	0.965	0.962	1.000	1.000	1.000	1.000	1.000	0.945
Average of Non-Municipalities	0.859	0.839	0.749	0.749	0.719	0.732	0.991	0.970	0.973	0.947	0.959	0.954
Average of Cities and Counties	0.852	0.845	0.777	0.781	0.760	0.785	0.994	0.979	0.973	0.960	0.972	0.962

Table 6 presents the gaps between the tax efficiency and financial effectiveness of each government. The overall efficiency of municipal governments was better than that of non-municipal governments. After introducing labor costs and other investments as inputs to generate self-raised tax revenues as the output in the first stage and using the output of the first stage as the input of the second stage to generate various expenditure as outputs, Taipei City, New Taipei City, and Penghu County were found to have greater competitive advantage.

The gaps between tax efficiency and financial effectiveness of all the cities and counties showed negative values between 2010 and 2015, suggesting that governments' first-stage tax efficiency was worse than second-stage financial effectiveness. In addition, the overall gap between tax efficiency and financial effectiveness widened during the research period; specifically, the gap between municipal governments narrowed, while that of non-municipal governments widened. Among all DMUs, of the six municipalities, cities with gaps greater than -0.300 included Taichung City, Tainan City and Kaohsiung City, with Tainan City as the worst. Of the 14 non-municipalities, Keelung City, Yilan County, Miaoli County, Changhua County, Yunlin County, Chiayi County, and Pingtung County had gaps greater than -0.300, and Pingtung County was the most severe.

Table 6 Overall efficiency and efficiency gap of the local governments in Taiwan

	Overall efficiency	2010 Gap	2011 Gap	2012 Gap	2013 Gap	2014 Gap	2015 Gap
Municipality							
Taipei City	0.996	0.000	-0.044	0.000	0.000	0.000	0.000
New Taipei City	0.992	0.000	0.000	-0.048	0.000	0.000	-0.053
Taoyuan City	0.963	0.000	0.005	0.106	0.018	-0.233	0.000
Taichung City	0.904	-0.369	-0.101	-0.214	-0.177	-0.222	0.000
Tainan City	0.824	-0.350	-0.328	-0.385	-0.423	-0.235	-0.222
Kaohsiung City	0.874	-0.264	-0.367	-0.242	-0.225	-0.176	-0.172
Average of Municipalities	0.925	-0.164	-0.139	-0.131	-0.135	-0.144	-0.075
Non- Municipality							
Keelung City	0.818	-0.110	-0.291	-0.260	-0.215	-0.302	-0.311
Yilan County	0.828	-0.330	0.040	-0.097	0.023	-0.250	-0.176
Hsinchu County	0.899	-0.246	-0.140	-0.157	-0.124	-0.211	-0.168
Hsinchu City	0.973	0.000	-0.049	-0.031	0.058	-0.009	-0.030
Miaoli County	0.812	-0.240	-0.279	-0.458	-0.442	-0.437	-0.404
Changhua County	0.805	-0.047	-0.312	-0.419	-0.306	-0.386	-0.272
Nantou County	0.854	-0.225	0.123	-0.226	-0.277	-0.133	-0.101
Yunlin County	0.816	-0.058	-0.310	-0.257	-0.362	-0.436	-0.477
Chiayi County	0.838	-0.136	-0.232	-0.342	-0.372	-0.374	-0.419
Chiayi City	0.904	-0.006	-0.213	-0.269	-0.251	-0.230	-0.116
Pingtung County	0.816	-0.146	0.000	-0.491	-0.473	-0.514	-0.362
Hualien County	0.864	-0.218	-0.072	-0.126	-0.028	-0.054	-0.054
Taitung County	0.968	-0.085	-0.070	0.000	-0.001	0.000	-0.228
Penghu County	0.986	0.000	-0.037	0.000	0.000	-0.035	0.017
Average of Non-Municipalities	0.870	-0.132	-0.132	-0.224	-0.198	-0.241	-0.222
Average of Cities and Counties	0.898	-0.142	-0.134	-0.196	-0.179	-0.212	-0.177

Note:1.The overall efficiency = 1/2 (tax efficiency + financial effectiveness)

2.gap = tax efficiency – financial effectiveness

4.2 Impulse Responses to Changes in the PVL

According to the data extracted from the official website of the Department of Land Administration, Ministry of Interior, the increase (decrease) in the PVL announced by local governments during 2010 and 2015 was between -0.13% and 42.84% (Table 7), indicating that the differences were relatively large. The overall response of governments' tax efficiency and financial effectiveness towards the policy change is shown in Table 8.

After the positive shock of the policy in the first year, tax efficiency was not substantially affected (a coefficient of 0); however, the impact of the policy led to negative responses in tax efficiency in the third year (-0.3472%), while financial effectiveness was not significantly affected (a coefficient of 0). The specific responses of the municipal and non-municipal government groups towards changes in their policies are presented in Table 9. After receiving a positive shock from the policy in the first year, the tax efficiency and financial effectiveness of all governments remained unaffected (coefficient 0). However, in the third year, the response to the tax efficiency of non-municipal governments was significantly negative (-0.0439%), while the response to their financial effectiveness was significantly positive (0.0137%). These findings could be attributed to the following reasons:

(A) This study used figures, announced by the governments, of the PVL as the tax base of the land value increment tax, which could be regarded as an overall economic variable; therefore, the announcement has the feature of an exogenous variable. When the economy is overheating, housing and land prices are likely to grow rapidly. If the government adjusts the tax system by raising the tax base of housing tax and land tax to increase tax revenue, serious inflation caused by economic overheating could be avoided. When economic growth declines, housing and land prices are also likely to decline. If the government gradually reduces the tax base of housing tax and land tax, thereby reducing tax revenue and increasing the disposable income of households, housing and land prices may be stimulated, leading to the promotion of economic growth and improvement in the government's tax efficiency and financial effectiveness.

Table 10 shows the year-on-year economic growth rate of Taiwan, as published by the National Statistics of the Republic of China. The economic growth of Taiwan peaked in 2010 (10.63%). However, local governments failed to take economic growth into consideration, and only increased the PVL by 1.63% on average (the lowest increase in the sample period); as a result, the responses of local governments' tax efficiency and financial effectiveness were not significant (a coefficient of 0). In addition, when the economic growth rate fell to 2.06% in 2012, local governments still failed to consider the overall economic environment, raising the PVL by 7.10% on average, which was inadvisable during an economic downturn, resulting in significantly negative responses in tax efficiency.

(B) In addition, neither municipal nor non-municipal governments seized the opportunity of the rapid economic growth rate of 2010, and only increased the PVL by 2.10% and 1.16%, respectively (the lowest increase in the sample period for each group); therefore, no significant responses were found in governments' tax efficiency and financial effectiveness (a coefficient of 0). During the economic downturn in 2012, non-municipal governments announced an increase in the PVL of 5.28% on average, resulting in significantly negative responses to tax efficiency; however, responses to financial effectiveness were found to be significantly positive. Compared with municipalities, more land is available in non-municipalities. Hence, increasing the PVL could drive the increase in other financial income of the government; therefore, the response to their financial effectiveness was significantly positive. Further, because of urbanization, the influence of the policies of non-municipal governments was relatively weak and the impact of economic growth on local policies was relatively low.

Table 7 Increase (Decrease) in the PVL between 2010 and 2015, Published by Local Governments in Taiwan (%)

	2010	2011	2012	2013	2014	2015
Municipality						
Taipei City	2.12	12.08	9.87	9.31	13.23	10.63
New Taipei City	2.30	15.33	12.19	11.24	17.44	15.17
Taoyuan City	4.58	6.89	7.84	10.85	22.77	12.56
Taichung City	2.89	7.77	15.70	4.79	24.43	11.06
Tainan City	0.56	0.60	3.87	4.71	11.09	12.49
Kaohsiung City	0.17	2.06	4.05	6.00	10.42	15.17
Average of Municipalities	2.10	7.46	8.92	7.82	16.56	12.85
Non-Municipality						
Keelung City	1.84	2.13	4.06	6.21	9.44	7.60
Yilan County	0.29	14.91	10.72	7.13	8.89	16.57
Hsinchu County	0.84	32.81	2.31	10.25	5.37	11.03
Hsinchu City	5.14	4.58	23.49	6.61	7.44	13.21
Miaoli County	2.67	5.57	6.35	7.35	7.92	8.68
Changhua County	0.60	3.92	4.49	5.24	6.82	7.27
Nantou County	0.51	1.68	3.71	4.89	9.25	9.42
Yunlin County	0.35	0.95	1.12	2.78	3.09	4.72
Chiayi County	0.36	1.83	2.85	4.05	5.38	5.19
Chiayi City	0.11	0.09	0.26	4.88	6.48	9.89
Pingtung County	−0.13	0.52	2.58	4.05	8.87	12.93
Hualien County	1.90	6.43	8.02	7.58	9.30	11.24
Taitung County	1.39	2.66	3.18	4.86	6.98	9.17
Penghu County	0.31	23.40	0.82	42.84	30.57	24.92
Average of Non-Municipalities	1.16	7.25	5.28	8.48	8.99	10.85
Average of Cities and Counties	1.63	7.35	7.10	8.15	12.77	11.85

Table 8 Responses of Local Governments' Tax Efficiency and Financial Effectiveness towards the Impact of Announcing Changes in the PVL

Years after policy	Coefficient			
	tax efficiency		financial effectiveness	
1(in 2010)	0.000000***		0.000000***	
2(in 2011)	0.032771		0.005790	
3(in 2012)	-0.003472**		0.004144	
4(in 2013)	-0.017503		-0.000804	
5(in 2014)	-0.007120		0.001080	
6(in 2015)	-0.002133		-0.003799	

Note: *** Significant at 1%；** Significantly at 5%.

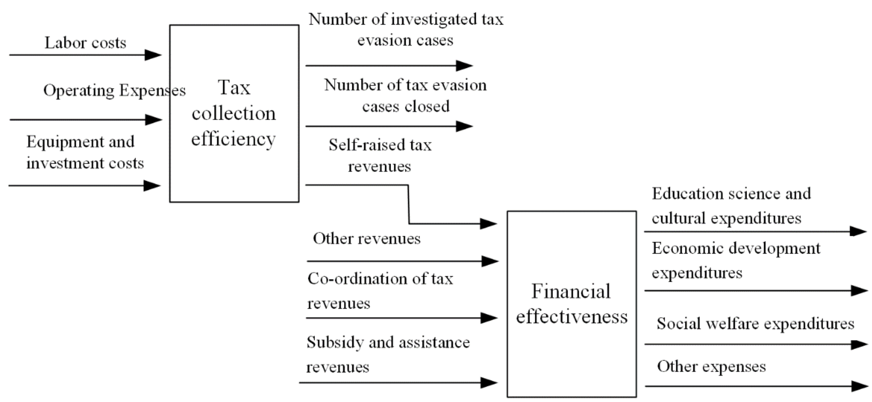
Table 9 Responses of Municipal and Non-Municipal Governments' Tax Efficiency and Financial Effectiveness towards the Impact of Announcing Changes in the PVL

Years after policy	Coefficient			
	tax efficiency		financial effectiveness	
	Municipality	Non-Municipality	Municipality	Non-Municipality
1(in 2010)	0.000000***	0.000000***	0.000000***	0.000000***
2(in 2011)	0.018913	0.007047	0.001748	-0.001550
3(in 2012)	-0.023014	-0.000439**	-0.001695	0.000137**
4(in 2013)	-0.018455	-0.023287	0.002306	0.001697
5(in 2014)	-0.018184	0.008400	0.011425	-0.004082
6(in 2015)	0.036797	-0.015289	-0.005375	0.007163

Note: *** Significant at 1%；** Significantly at 5%.

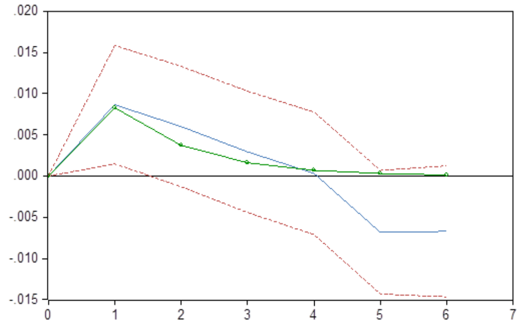
Table 10 Economic Growth Rate in Taiwan between 2010 and 2015 (%)

	2010	2011	2012	2013	2014	2015
Economic Growth Rate (YOY)	10.63	3.80	2.06	2.20	4.02	0.72



Figures 2 and 3 show the trajectory of the responses to tax efficiency and financial effectiveness towards the shock of government policies within a 95% confidence interval. The confidence interval was elongated during the forecast period, which increases uncertainty in the length of the response period. In addition, the announcement of the increase (decrease) in the PVL in 2012 affected the tax efficiency of local governments as well as of non-municipal governments, triggering a negative response. The impact also triggered a positive response in the financial effectiveness of non-municipal governments.

Fig 2. Trajectory of the Response of Governments' Tax Efficiency towards the Announcement of Increase (Decrease) in the PVL



Response to Cholesky One S.D. Innovations 95% Marginal confidence bands of second-stage to DUMMY
---------- Estimation at a 95% Confidence Interval
Estimated Value

Fig 3. Trajectory of the Response of Governments' Financial Effectiveness towards the Announcement of Increase (Decrease) in the PVL

5 Concluding Remarks

The results of the first-stage analysis showed a decline in the overall tax efficiency of local governments. Specifically, the tax efficiency of municipalities (non-municipalities) was found to be increasing (decreasing). The results of the second-stage analysis showed that the overall financial effectiveness of local governments was reducing. The financial effectiveness of both municipalities and non-municipalities was found to be deteriorating, suggesting that the efficiency and effectiveness of local governments requires further improvement. From the perspective of individual DMUs, the tax efficiency and financial effectiveness of Taipei City and New Taipei City were found to be superior to those of the other cities and counties; hence, they can serve as benchmarks for local governments. By contrast, the tax efficiency and financial effectiveness of Yilan County and Changhua County were found to be the lowest, as these two counties rely on agriculture as a source of development, which makes growth harder to achieve and leads to lower effectiveness and efficiency.

Overall, the tax efficiency and financial effectiveness of municipal governments were better than those of non-municipal governments. The governments of Taipei City, New Taipei City, and Penghu County had greater competitive advantage, after combining labor costs and other investments to generate self-raised tax revenues, which was thereafter transferred into various expenditure as outputs; hence, they may serve as benchmarks for other governments. The gaps between tax efficiency and financial effectiveness suggested that local governments' tax efficiency was inferior to their financial effectiveness. In addition, the gap between the tax efficiency and financial effectiveness of non-municipal governments appeared to be expanding. That gap was the greatest in Tainan City and Pingtung County, suggesting that these two DMUs should develop policies and targets to enhance the tax efficiency and effectiveness of public revenue and expenditure. Hence, local governments should improve tax officers' taxation and auditing skills to increase tax revenues and reduce the expanding gap. Finally, the impulse response analysis results showed negative responses to the overall tax efficiency of local governments and the tax efficiency of non-municipal governments when impacted by an adjusting PVL and positive responses to the financial effectiveness of non-municipal governments. These results can be used by governments in all countries to develop tax policies that match the growth of the economy.

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