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Spatial Spillover Effects of Fiscal Expenditure on Employed Population in Taiwan

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Abstract

This study aims to examine the impact of local government fiscal expenditure on employment in Taiwan and to investigate whether such effects exhibit spatial spillovers. Employment is a crucial foundation for economic development and social stability, and understanding how fiscal expenditure influences the labor market provides valuable implications for policymaking. Using panel data from 22 counties and cities in Taiwan covering the period 2000–2023, with data obtained from the Directorate General of Budget, Accounting and Statistics (DGBAS), this study constructs a contiguity-based spatial weight matrix. The empirical tests reveal that the Spatial Durbin Model (SDM) provides greater explanatory power than the Spatial Lag Model (SLM) and the Spatial Error Model (SEM). The SDM with spatial and time fixed effects is ultimately adopted, followed by an effects decomposition analysis. The results indicate that expenditures on education, science, and culture, as well as economic development, have stable and positive impacts on employment, accompanied by significant spillover effects. Pension and retirement benefits expenditures also exert positive effects. In contrast, general administrative expenditures show negative impacts, while social welfare expenditures have positive local effects but negative spillovers to neighboring regions. Community development and environmental protection expenditures mainly contribute through positive externalities.

JEL classification numbers: C33, C21, E62.
Keywords: Fiscal expenditure, Employment, Spatial spillover effects, Spatial Durbin Model.

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1. Introduction

Employment serves as a cornerstone for both economic growth and social stability, as it reflects the actual mobilization of labor resources while directly influencing household income, domestic consumption, and overall productivity (OECD, 2023). Stable and sufficient employment not only reduces the risks of income inequality and unemployment but also constitutes the fiscal foundation of government tax revenues. Consequently, governments across the world commonly regard increasing the employment rate as one of their core policy objectives.

To promote local economic growth and employment development, public expenditure has become one of the most widely used policy instruments. At the regional level, fiscal spending on infrastructure, education, healthcare, subsidies, and entrepreneurial support can directly or indirectly create job opportunities. However, modern regional economic activities are highly interconnected, meaning that public expenditure in one locality may generate significant spatial spillover effects on neighboring regions through mechanisms such as transportation networks, labor mobility, and industrial relocation (Zhang, Qiu, & Liu, 2025).

Ignoring such spatial effects may lead to biased policy design and misjudged policy outcomes. For instance, Dian, Li, and Song (2025) highlight that in China, increased local fiscal spending not only boosts economic activity within a region but also generates positive employment spillovers for neighboring counties through interregional linkages. Similarly, Wang, Jiao, Cai, and Zhu (2025) demonstrate that fiscal policies that overlook regional interdependencies risk resource duplication and weakened policy outcomes. Tram and Ngoc (2025), studying ASEAN countries, further show that fiscal and financial expenditures exhibit spatial dependence in influencing both employment and green transition outcomes.

Nevertheless, empirical studies focusing on Taiwan remain relatively scarce, especially in systematically examining the spatial relationship between fiscal expenditure and employment. Given the substantial heterogeneity among Taiwan's counties and cities in terms of demographic structures, industrial compositions, and fiscal capacities, a better understanding of the spatial transmission mechanisms of fiscal expenditure is essential to improving policy effectiveness and reducing the risk of resource misallocation.

Accordingly, this study adopts county- and city-level data from Taiwan and applies spatial econometric models to investigate both the direct and indirect (spillover) effects of fiscal expenditure on employment. By bridging theoretical and empirical perspectives, this research aims to fill the gap in existing literature on Taiwan while providing empirical evidence to support local governments in designing employment-promotion policies and resource allocation strategies.

Specifically, the objectives of this paper are twofold: (1) to examine the direct effects of fiscal expenditure on local employment at the county/city level, and (2) to explore the potential neighboring effects, namely the spatial spillover impacts of fiscal expenditure on employment in adjacent regions. The next section reviews the relevant literature and develops the research hypotheses, followed by a discussion

of the methodology, including data, variables, and empirical models. The empirical analysis covers descriptive statistics, correlation analysis, estimation results of the Spatial Durbin Model (SDM), and a decomposition of direct and spillover effects. Finally, the paper concludes with key findings and policy implications.

2. Literature Review and Hypothesis Development

2.1 The impact of local fiscal expenditure on employment

Public expenditure is a primary instrument through which governments promote local development and improve public welfare, and it exerts both direct and indirect effects on job creation. According to OECD (2023), government spending in areas such as education, infrastructure, and social welfare enhances human capital accumulation, improves infrastructure conditions, and stimulates local consumption demand, thereby strengthening employment capacity and attractiveness at the local level.

Specifically, education and cultural expenditures help improve the quality of human capital and technological capabilities, which are particularly important for job creation in innovative industries and high value-added sectors (Liang & Chen, 2024). Social welfare and community development expenditures can reduce poverty and protect vulnerable groups, thereby enhancing employment stability and labor force participation. Moreover, infrastructure and economic development expenditures not only generate short-term construction jobs but also contribute to the long-term formation of industrial clusters and logistical connectivity, attracting investment and increasing labor demand.

Previous research underscores the importance of local government fiscal spending. Zou (2024), using county-level data from China, found that local fiscal expenditure has a significant positive effect on employment, with infrastructure and education investments having the strongest impacts on employment growth. This study therefore posits that public expenditure can enhance regional productivity and human capital, thereby expanding employment opportunities. Accordingly, the first hypothesis is proposed:

Hypothesis 1: County/city fiscal expenditure (general government expenditure, economic development expenditure, education, science and culture expenditure, social welfare expenditure, community development and environmental protection expenditure, and pension and retirement expenditure) significantly affects local employment.

2.2 The spatial spillover effects of fiscal expenditure in neighboring regions

In regional economic systems, counties and cities are often closely linked through economic and social interactions. Mechanisms such as transportation, population mobility, industrial relocation, and labor market competition mean that the policy outcomes of one jurisdiction may spill over to neighboring areas, generating spatial spillover effects. For example, when a county significantly increases its investment

in education, infrastructure, or social welfare, the benefits may extend to surrounding regions, indirectly influencing their employment structures and opportunities (Zhang, Zhang, Li, & Zeng, 2020).

Tian, Teng, and Guo (2021) found that education expenditure in Chinese prefecture-level cities exhibits significant spatial dependence, as high educational investment in neighboring regions attracts population inflows and reshapes the local employment and demographic structure. Wu and Zhu (2021), using a Spatial Durbin Model, confirmed that fiscal expenditure on higher education generates significant spillovers, whereby the spending level of neighboring cities influences local educational attainment and employment choices.

Similarly, Ojede et al. (2018), analyzing U.S. state-level data, demonstrated that productive expenditures such as infrastructure and education yield positive spillover effects on the economic growth and labor markets of neighboring states. Zhang, Zhang, Li, and Zeng (2020), focusing on the Yangtze River Delta, further showed that public infrastructure investment not only strengthens local development but also stimulates surrounding regions' investment and employment growth.

These studies consistently highlight that the impacts of fiscal expenditure extend beyond a single jurisdiction, exerting cross-regional influence. Incorporating the fiscal spending of neighboring counties and cities is therefore crucial for understanding variations in local employment. Based on this reasoning, the second hypothesis is proposed:

Hypothesis 2: Fiscal expenditure in neighboring counties/cities (general government expenditure, economic development expenditure, education, science and culture expenditure, social welfare expenditure, community development and environmental protection expenditure, and pension and retirement expenditure) significantly affects local employment.

3. Methodology

3.1 Data and procedure

This study employs panel data from 22 counties and cities in Taiwan covering the period from 2000 to 2023 as the research sample. According to Taiwan's current administrative divisions, the local government system comprises six special municipalities, thirteen counties, and three provincial cities, totaling 22 jurisdictions, which represent the highest level of local self-government. The statistical data were primarily obtained from the Directorate General of Budget, Accounting and Statistics (DGBAS), which, in 2024, released the "Statistical Database of Major Indicators of Counties and Cities." This database provides comprehensive information on fiscal revenues and expenditures, socioeconomic structures, and industrial profiles across counties and cities over multiple years. The dataset is highly consistent and comparable, making it suitable for econometric analysis using panel data.

The variable "employment population" used in this study was retrieved from the aforementioned statistical system, covering the total number of employed persons in Taiwan from 2000 to 2023, measured in thousands. Table 1 summarizes the employment population by year and serves as the primary dependent variable of this study.

Table 1 illustrates the changes in Taiwan's employment population from 2000 to 2023, with data presented in thousands. Over the long term, Taiwan's employment population increased steadily from 9,510 thousand persons in 2000 to 11,562 thousand persons in 2023, marking an overall growth of 2,052 thousand. This trend reflects the expansion of the labor market and the possibility of structural adjustments. The only significant downturn occurred in 2009, when employment fell from 10,424 thousand in 2008 to 10,301 thousand in 2009 due to the global financial crisis. In other years, employment generally exhibited positive growth, suggesting a degree of resilience and adaptability in Taiwan's economic system.

Particular attention should be paid to developments after 2008. Although the global financial crisis imposed certain shocks on Taiwan, the government promptly launched expansionary fiscal policies, such as the "Economic Stimulus Public Construction Expansion Plan" and the "Domestic Demand Expansion Plan," to boost public investment and create short-term employment opportunities. These measures may have contributed to the rapid rebound of the employment population to 10,515 thousand in 2010. Furthermore, during the COVID-19 pandemic (2020–2022), Taiwan's employment population experienced some fluctuations, declining slightly to 11,480 thousand in 2021 and 11,453 thousand in 2022. Nonetheless, the overall level remained relatively stable, and by 2023, employment had risen to a historical peak of 11,562 thousand. This indicates that while the pandemic negatively affected certain labor-intensive industries, the overall labor market structure in Taiwan retained a considerable degree of resilience.

Table 1: Employment Population in Taiwan, 2000–2023 (thousand persons)

Year	Employment Population (thousand persons)	Year	Employment Population (thousand persons)	Year	Employment Population (thousand persons)
2000	9510	2008	10424	2016	11294
2001	9400	2009	10301	2017	11379
2002	9471	2010	10515	2018	11461
2003	9589	2011	10731	2019	11526
2004	9805	2012	10883	2020	11536
2005	9961	2013	10990	2021	11480
2006	10131	2014	11102	2022	11453
2007	10316	2015	11222	2023	11562

Source: Directorate General of Budget, Accounting and Statistics (DGBAS), Executive Yuan (2024).

This study conducts a rigorous series of statistical inferences and model-building procedures grounded in the theoretical framework of spatial econometrics. To capture the potential spatial dependence and interactions among Taiwan's counties and cities, a spatial weight matrix was first constructed as the analytical foundation. Specifically, a contiguity matrix was employed, in which weights were assigned based on whether counties and cities share geographical boundaries, thereby realistically reflecting the spatial interdependencies across regions.

In terms of model selection, the Spatial Durbin Model (SDM) was initially adopted as the primary analytical framework. The SDM allows both independent variables and their spatial lag terms to jointly influence the dependent variable, thereby comprehensively capturing the spatial diffusion effects of fiscal expenditure. At the same time, a series of diagnostic tests were conducted to assess whether the SDM could be simplified to a Spatial Autoregressive Model (SAR) or a Spatial Error Model (SEM), ensuring that the model framework chosen most accurately fits the data characteristics.

Furthermore, to determine the appropriateness of specifying individual effects, the Hausman test was applied to compare fixed-effects and random-effects specifications, thereby identifying the optimal design for the panel data structure. To evaluate the overall goodness of fit and explanatory power of the models, indicators including the log-likelihood value, the Akaike Information Criterion (AIC), and the Bayesian Information Criterion (BIC) were compared. The results indicated that the SDM with both spatial and time fixed effects provided the most robust and explanatory specification, and it was thus selected as the core model for subsequent empirical analysis.

After model estimation, this study further performed a decomposition of spatial effects, separating the impacts of each explanatory variable on employment into direct effects, indirect effects (i.e., spatial spillover effects), and total effects. Such decomposition enables a clearer understanding of how different types of fiscal expenditure influence employment dynamics both within a given region and through interactions with neighboring regions. Finally, based on the empirical results, this study presents research conclusins and policy implications, with the aim of offering concrete evidence and reference for local governments in designing employment-related policies and allocating fiscal resources more effectively.

3.2 Research variables

The definitions and descriptions of the dependent and independent variables used in the empirical model of this study are as follows:

3.2.1 Dependent variable

Employment Population (thousand persons) ($\boldsymbol{EP_{it}}$): Refers to the number of employed persons aged 15 and above in county/city i of Taiwan in year t, including individuals engaged in paid work and those working more than 15 hours as unpaid family workers.

3.2.2 Independent variables related to fiscal expenditure

General Government Expenditure (million NTD) ($\boldsymbol{GGE_{it}}$): Refers to the general government expenditure of county/city i in year t, including spending on the exercise of political authority, administration, civil affairs, and finance (excluding police expenditure).

Economic Development Expenditure (million NTD) ($\boldsymbol{EDE_{it}}$): Refers to the economic development expenditure of county/city i in year t, including spending on agriculture, industry, transportation, and other economic services.

Education, Science, and Culture Expenditure (million NTD) ($\boldsymbol{ESCE_{it}}$): Refers to the expenditure of county/city i in year t on education, science, culture, and related subsidies.

Social Welfare Expenditure (million NTD) ($\boldsymbol{SWE_{it}}$): Refers to the social welfare expenditure of county/city i in year t, including spending on social insurance, social assistance, welfare services, national employment programs, healthcare, and related subsidies.

Community Development and Environmental Protection Expenditure (million NTD) ($\boldsymbol{CEE_{it}}$): Refers to the expenditure of county/city i in year t on community development and environmental protection, including related programs and subsidies.

Retirement and Pension Expenditure (million NTD) ($\boldsymbol{RPE_{it}}$): Refers to the retirement and pension expenditure of county/city i in year t, including spending on pensions and allowances for retired public servants and teachers.

3.3 Empirical model

The construction of the model in this study is based on Tobler's First Law of Geography. Tobler (1970) pointed out: "Everything is related to everything else, but near things are more related than distant things." This theory emphasizes that neighboring regions are more strongly connected, implying that counties and cities with geographical proximity tend to exhibit stronger interactions and linkages in economic, social, and policy dimensions. This characteristic of spatial dependence constitutes an important foundation for explaining the possible cross-regional impacts between local fiscal expenditure and employment population. To capture such spatial effects, this study adopts the Spatial Durbin Model (SDM) proposed by LeSage and Pace (2009), which is specified as follows:

$$EP_{it} = \rho \sum_{j=1}^{N} W_{ij} EP_{jt} + \alpha + \beta_1 GGE_{it} + \beta_2 EDE_{it} + \beta_3 ESCE_{it} + \beta_4 SWE_{it} + \beta_5 CEE_{it} + \beta_6 RPE_{it} + \theta_1 \sum_{j=1}^{N} W_{ij} GGE_{jt} + \theta_2 \sum_{j=1}^{N} W_{ij} EDE_{jt} + \theta_3 \sum_{j=1}^{N} W_{ij} ESCE_{jt} + \theta_4 \sum_{j=1}^{N} W_{ij} SWE_{jt} + \theta_5 \sum_{j=1}^{N} W_{ij} CEE_{jt} + \theta_6 \sum_{j=1}^{N} W_{ij} RPE_{jt} + \mu_i + \varepsilon_{it}$$

$$\mathbf{i} \neq \mathbf{j}$$

Here, EP_{it} denotes the employment population of county/city i in year t. The indices i, j represent Taiwan's counties and cities, while t refers to the year (t = 2000–2023).

W_{ij} is the spatial weight matrix, which is a square matrix that is symmetric about the diagonal, with both the number of rows and columns equal to the number of counties and cities (22 in this study). This study employs the Queen contiguity principle to construct the spatial structure: if two counties or cities share a geographical border or corner, they are considered neighbors, and the corresponding element W_{ij} = 1; otherwise, it is 0. For the same county/city ($i = j$), no spatial adjacency is assumed, and thus all diagonal elements are 0. For Taiwan's three offshore counties (Penghu, Kinmen, and Lienchiang), which do not share land borders with other regions, their adjacency values with other counties/cities are also set to 0. The spatial weight matrix is therefore defined as:

$$W_{ij} = \begin{cases} 1, & regions\ i\ and\ j\ are\ neighboring\ regions \\ 0, & otherwise \end{cases}$$

The term $W_{ij} EP_{jt}$ represents the spatially lagged dependent variable, which is an endogenous variable indicating the impact of employment population in neighboring region j on that of region i.

α is the constant term. The parameters β_k are the coefficients to be estimated, representing the direct impacts of the independent variables on local employment population. The independent variables include: GGE_{it} (General Government Expenditure), EDE_{it} (Economic Development Expenditure), $ESCE_{it}$ (Education, Science, and Culture Expenditure), SWE_{it} (Social Welfare Expenditure), CEE_{it} (Community Development and Environmental Protection Expenditure), and RPE_{it} (Retirement and Pension Expenditure).

Within this framework, the significance and sign of $\boldsymbol{\rho}$ can be used to test whether employment population exhibits spatial dependence. If $\boldsymbol{\rho} > 0$, it indicates that employment in neighboring counties/cities has a positive spillover effect; if $\boldsymbol{\rho} < 0$, it may reflect competitive effects among regions.

On the other hand, the estimates of $\boldsymbol{\theta}$ reveal the direction and magnitude of the impacts of fiscal expenditure in neighboring regions on local employment. A positive $\boldsymbol{\theta}$ suggests that fiscal spending in neighboring regions promotes local employment, indicating positive spillover effects; conversely, a negative $\boldsymbol{\theta}$ implies potential crowding-out effects.

$\boldsymbol{\mu_i}$ denotes county/city individual effects, which control for unobservable heterogeneity across regions.

$\boldsymbol{\varepsilon_{it}}$ is the random error term, assumed to be independently and identically distributed.

In sum, this model design enables simultaneous capture of both local and neighboring fiscal expenditure effects on employment population, thereby clarifying the direct and indirect impacts of different types of fiscal spending under regional interactions. This provides a highly suitable framework for analyzing the dynamics of employment and the effects of fiscal policy among Taiwan's 22 counties and cities.

4. Results

4.1 Descriptive statistics

Table 2 presents the descriptive statistics of the sample used in this study, covering 528 observations from 22 counties and cities in Taiwan during the period 2000–2023. The average employment population (EP) was 484.93 thousand persons, with a standard deviation of 499.01 thousand, indicating substantial variation in employment size across counties and cities. The minimum was only 2 thousand persons, while the maximum reached 2,002 thousand, reflecting the structural disparity in employment between the six metropolitan municipalities and other regions.

The average general government expenditure (GGE) and economic development expenditure (EDE) were 8,106.39 million NTD and 7,290.28 million NTD, respectively, with standard deviations close to their means. This suggests a high degree of inequality in government spending levels among counties and cities. Education, science, and culture expenditure (EESC) had an average of 15,524.99 million NTD, but with even greater variation, reaching a maximum of 73,384.66 million NTD. This indicates that certain municipalities concentrate heavily on education- and culture-related spending.

Social welfare expenditure (SWE), community development and environmental protection expenditure (CEE), and retirement and pension expenditure (RPE) had average values of 6,368.21 million NTD, 2,421.68 million NTD, and 2,714.64 million NTD, respectively. All three variables exhibited high dispersion, suggesting significant disparities in welfare spending, infrastructure and environmental

maintenance, and pension resources across counties and cities. Overall, the descriptive statistics highlight pronounced heterogeneity among Taiwan's counties and cities in both population size and fiscal expenditure structure, justifying the application of spatial econometric models for further analysis.

Table 3 reports the results of the Pearson correlation analysis. The findings show that employment population (EP) is highly and significantly positively correlated with all categories of fiscal expenditure. The strongest correlation is with general government expenditure (GGE) ($r = 0.933$, $p < 0.01$), indicating a high degree of synchronicity between large-scale government spending and employment size. Similarly, EP is strongly correlated with education, science, and culture expenditure (EESC) ($r = 0.912$, $p < 0.01$), reflecting the role of educational and cultural investments in enhancing human capital accumulation and industrial development, thereby generating employment opportunities.

Other categories, including economic development expenditure (EDE), social welfare expenditure (SWE), and community development and environmental protection expenditure (CEE), also exhibit correlations with EP above 0.80, further demonstrating the positive linkages between government spending and employment. Although retirement and pension expenditure (RPE) is likewise significantly positively correlated with EP ($r = 0.773$, $p < 0.01$), its correlation is relatively weaker, which may reflect the fact that such spending is primarily directed toward protecting existing labor rather than directly creating new employment opportunities.

In sum, the correlation analysis supports the study's hypothesis that local governments' fiscal expenditures across different categories are closely associated with employment size. This provides preliminary statistical evidence for the subsequent causal testing through spatial econometric models.

Table 2: Summary of descriptive statistics

Variables	Obs.	Mean	Std. Dev.	Min.	25th Percentile	Median	75th Percentile	Max.
EP	528	484.93	499.01	2.00	148.50	251.00	848.50	2002.00
GGE	528	8106.39	8064.79	386.45	3240.45	4328.66	10367.42	50860.14
EDE	528	7290.28	7622.95	541.91	2572.15	4207.69	8151.56	46357.08
ESCE	528	15524.99	17128.55	400.57	4728.63	7570.59	19479.79	73384.66
SWE	528	6368.21	8320.84	180.82	1754.21	2854.05	6055.50	44720.84
CEE	528	2421.68	3805.22	63.44	324.42	690.35	1884.85	20164.01
RPE	528	2714.64	2215.37	8.32	1338.73	2110.98	3706.69	12704.64

Note: Obs.: Observations.

TWD: New Taiwan dollar (equal to USD 0.030). EP = Employment Population (thousand persons); GGE = General Government Expenditure (million NTD); EDE = Economic Development Expenditure (million NTD); EESC = Education, Science, and Culture Expenditure (million NTD); SWE = Social Welfare Expenditure (million NTD); CEE = Community Development and Environmental Protection Expenditure (million NTD); RPE = Retirement and Pension Expenditure (million NTD).

Table 3: Pearson correlation analysis

	EP	GGE	EDE	ESCE	SWE	CEE	RPE
EP	1						
GGE	.933**	1					
EDE	.820**	.916**	1				
ESCE	.912**	.973**	.909**	1			
SWE	.805**	.922**	.866**	.942**	1		
CEE	.855**	.943**	.877**	.932**	.917**	1	
RPE	.773**	.693**	.593**	.617**	.562**	.601**	1

Note: ** $p<0.01$.

TWD: New Taiwan dollar (equal to USD 0.030). EP = Employment Population (thousand persons); GGE = General Government Expenditure (million NTD); EDE = Economic Development Expenditure (million NTD); EESC = Education, Science, and Culture Expenditure (million NTD); SWE = Social Welfare Expenditure (million NTD); CEE = Community Development and Environmental Protection Expenditure (million NTD); RPE = Retirement and Pension Expenditure (million NTD).

4.2 Results of the Wald test and Likelihood-ratio test

According to the theoretical framework of LeSage and Pace (2009) and Elhorst (2010), the Spatial Durbin Model (SDM), by incorporating spatial lags of both the dependent and independent variables, provides greater explanatory power and flexibility. However, to verify its necessity, this study employs the Wald test and the Likelihood-Ratio (LR) test to compare the SDM with the Spatial Lag Model (SLM) and the Spatial Error Model (SEM), in order to evaluate whether the SDM can be simplified. If the null hypothesis H_0: $\theta = 0$ is rejected, it indicates that the spatial lag terms of the independent variables exert significant influence, and thus the SDM cannot be simplified into alternative models.

First, in comparing the SLM and SDM, the test results are reported in Table 4. Under the spatial fixed-effects model, the Wald test yields $\chi^2 = 307.32$, $p<0.001$, while the LR test gives $\chi^2 = 217.67$, $p<0.001$, both strongly favoring the SDM over the SLM. For the time fixed-effects specification, the Wald test result is $\chi^2 = 177.05$, $p<0.001$, and the LR test result is $\chi^2 = 88.68$, $p<0.001$, again rejecting the simplification hypothesis. When both spatial and time fixed effects are included, the Wald test yields $\chi^2 = 102.05$, $p<0.001$, and the LR test produces $\chi^2 = 81.18$, $p<0.001$, confirming the necessity of the SDM. As for the random-effects model, the Wald test result is $\chi^2 = 292.65$, $p<0.001$, while the LR test is $\chi^2 = 208.86$, $p<0.001$, again showing that the SDM is preferable to the SLM. Taken together, under all four specifications, the results are highly consistent, indicating that the spatial lag terms of the independent variables play an indispensable role in explaining employment.

Further, in comparing the SEM and SDM, the results are reported in Table 5. Under the spatial fixed-effects model, the Wald test statistic is $\chi^2 = 63.71$, $p<0.001$, and the LR test statistic is $\chi^2 = 60.21$, $p<0.001$, clearly indicating that the SDM outperforms the SEM. In the time fixed-effects specification, the Wald test yields $\chi^2 = 321.59$, $p<0.001$, while the LR test gives $\chi^2 = 130.63$, $p<0.001$, showing that even after controlling for time heterogeneity, the SEM remains insufficient compared to the SDM. Under the spatial and time two-way fixed-effects model, the Wald test result

is $\chi^2 = 70.00$, $p<0.001$, and the LR test result is = 1742.58, $p<0.001$, again supporting the superior explanatory power of the SDM. Finally, in the random-effects model, the Wald test yields $\chi^2 = 62.18$, $p<0.001$, and the LR test produces $\chi^2 = 1498.85$, $p<0.001$, further confirming the significant advantage of the SDM.

In summary, across spatial fixed, time fixed, two-way fixed, and random-effects specifications, both the Wald and LR tests consistently reject the hypothesis that the SDM can be simplified to either the SLM or SEM. This indicates that the coefficient vector of the spatially lagged independent variables (θ) is significantly different from zero. In other words, the SDM is statistically well supported and is capable of capturing both the direct effects of local fiscal expenditure on employment as well as the indirect spillover effects from neighboring regions. Compared with the SLM, which only considers spatial dependence of the dependent variable, or the SEM, which only addresses spatial autocorrelation in the error term, the SDM demonstrates higher applicability and completeness. Therefore, this study adopts the SDM as the core estimation model and uses it as the foundation for subsequent empirical analysis.

Table 4: Spatial lag model (SLM)

Variables	Model 1 SLM with spatial fixed-effects		Model 2 SLM with time fixed-effects		Model 3 SLM with spatial and time fixed-effects		Model 4 SLM with random-effects	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
GGE	-0.003**	0.001	0.031***	0.004	-0.003**	0.001	-0.003**	0.001
EDE	0.002***	0.000	-0.011***	0.002	0.002***	0.000	0.002***	0.000
ESCE	0.007***	0.001	0.026***	0.002	0.009***	0.001	0.007***	0.001
SWE	0.002**	0.001	-0.023***	0.002	0.002**	0.001	0.001*	0.001
CEE	0.005**	0.002	-0.001	0.004	0.001	0.001	0.005**	0.002
RPE	0.008***	0.001	0.051***	0.003	0.011***	0.001	0.009***	0.001
Constant							254.865**	74.745
n		528		528		528		528
Spatial ρ	0.183***	0.028	-0.209***	0.018	0.158***	0.031	0.181***	0.029
within R^2	0.7417		0.4219		0.7383		0.742	
between R^2	0.8624		0.9724		0.8712		0.8551	
overall R^2	0.8226		0.9463		0.8330		0.8219	
Log-likelihood	-2492.720		-3218.539		-2408.813		-2594.516	
Wald test	$H_0: \theta = 0$ $x^2 = 307.32^{***}$ p-value = 0.000		$H_0: \theta = 0$ $x^2 = 177.05^{***}$ p-value = 0.000		$H_0: \theta = 0$ $x^2 = 102.05^{***}$ p-value = 0.000		$H_0: \theta = 0$ $x^2 = 292.65^{***}$ p-value = 0.000	
Likelihood-ratio test	H_0: SLM nested within SDM LR $x^2 = 217.67^{***}$ p-value = 0.000		H_0: SLM nested within SDM LR $x^2 = 88.68^{***}$ p-value = 0.000		H_0: SLM nested within SDM LR $x^2 = 81.18^{***}$ p-value = 0.000		H_0: SLM nested within SDM LR $x^2 = 208.86^{***}$ p-value = 0.000	

Note: * $p<0.05$; ** $p<0.01$; *** $p<0.001$. TWD: New Taiwan dollar (equal to USD 0.030).
SLM: Spatial lag model. SDM: Spatial Durbin model. Coef.:Coefficient. Std. Err.: Standard error.
GGE = General Government Expenditure (million NTD); EDE = Economic Development Expenditure (million NTD); EESC = Education, Science, and Culture Expenditure (million NTD); SWE = Social Welfare Expenditure (million NTD); CEE = Community Development and Environmental Protection Expenditure (million NTD); RPE = Retirement and Pension Expenditure (million NTD).

Table 5: Spatial error model (SEM)

Variables	Model 5 SEM with spatial fixed-effects		Model 6 SEM with time fixed-effects		Model 7 SEM with spatial and time fixed-effects		Model 8 SEM with random-effects	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
GGE	0.001	0.001	0.012*	0.005	0.000	0.001	0.001	0.001
EDE	0.001***	0.000	-0.006**	0.002	0.002***	0.000	0.001***	0.000
ESCE	0.007***	0.000	0.029***	0.002	0.008***	0.001	0.008***	0.001
SWE	0.003***	0.001	-0.019***	0.002	0.002***	0.001	0.003***	0.001
CEE	-0.003*	0.001	-0.002	0.004	-0.001	0.001	-0.003*	0.001
RPE	0.010***	0.001	0.057***	0.003	0.010***	0.001	0.010***	0.001
Constant							308.929***	72.999
n		528		528		528		528
Spatial λ	0.667***	0.035	-0.599***	0.068	0.407***	0.055	0.668***	0.036
within R^2		0.7337		0.5271		0.7429		0.7337
between R^2		0.8979		0.9488		0.8956		0.8988
overall R^2		0.8592		0.9267		0.8587		0.8605
Log-likelihood		-2413.988		-3239.512		-2396.525		-2518.693
Wald test	H_0: $\theta+\rho\beta=0$ x^2 = 63.71*** p-value = 0.000		H_0: $\theta+\rho\beta=0$ x^2 = 321.59*** p-value = 0.000		H_0: $\theta+\rho\beta=0$ x^2 = 70.00*** p-value = 0.000		H_0: $\theta+\rho\beta=0$ x^2 = 62.18*** p-value = 0.000	
Likelihood-ratio test	H_0: SEM nested within SDM LR x^2 = 60.21*** p-value = 0.000		H_0: SEM nested within SDM LR x^2 = 130.63*** p-value = 0.000		H_0: SEM nested within SDM LR x^2 = 1742.58*** p-value = 0.000		H_0: SEM nested within SDM LR x^2 = 1498.85*** p-value = 0.000	

Note: * p<0.05; ** p<0.01; *** p<0.001
TWD: New Taiwan dollar (equal to USD 0.030). SEM: Spatial error model. SDM: Spatial Durbin model. Coef.:Coefficient. Std. Err.: Standard error. GGE = General Government Expenditure (million NTD); EDE = Economic Development Expenditure (million NTD); EESC = Education, Science, and Culture Expenditure (million NTD); SWE = Social Welfare Expenditure (million NTD); CEE = Community Development and Environmental Protection Expenditure (million NTD); RPE = Retirement and Pension Expenditure (million NTD).

4.3 Results of the Hausman test

To further determine whether the Spatial Durbin Model (SDM) in the empirical estimation should adopt fixed effects or random effects, this study applies the test proposed by Hausman (1978) for model selection. The Hausman test is primarily used to examine whether individual (county/city) or time effects are correlated with the explanatory variables. If such correlation is significant, a fixed-effects model should be adopted to avoid estimation bias; if not significant, the random-effects model is considered more appropriate.

Table 6 presents the test results under three different model specifications. First, in comparing the SDM with spatial fixed effects against the SDM with random effects, the Hausman test statistic is 1.67 with a corresponding p-value of 0.9476, indicating that the null hypothesis (random-effects model) cannot be rejected. This supports

the adoption of the SDM with random effects. In the comparison between the SDM with time fixed effects and the random-effects model, the Hausman test statistic reaches 23,263.28 with a p-value of 0.0000, clearly rejecting the null hypothesis and favoring the SDM with time fixed effects. Finally, in the comparison of the SDM with both spatial and time fixed effects against the random-effects model, the Hausman test statistic is 80.91 with a p-value of 0.0000, again rejecting the null hypothesis and indicating that the SDM with spatial and time fixed effects is more appropriate.

In summary, the results suggest that when the model includes only spatial fixed effects, the random-effects specification is sufficient to explain the characteristics of the data. However, when time or both spatial and time fixed effects are involved, the fixed-effects model must be adopted to avoid estimation bias. Therefore, depending on the model structure, the specification of the SDM should be adjusted according to the Hausman test results to ensure the appropriateness and consistency of the model estimation.

Table 6: Results of the Hausman test

	Hausman test		**Result**
	x^2	p-value	
SDM with spatial fixed-effects v.s. SDM with random-effects	1.67	0.9476	$H_0: \mathrm{E}(x_{it}, \mu_i) = 0$ The null hypothesis (random-effects model) cannot be rejected; SDM with random effects is adopted.
SDM with time fixed-effects v.s. SDM with random-effects	23263.28	0.0000	$H_0: \mathrm{E}(x_{it}, \mu_i) = 0$ The null hypothesis (random-effects model) is rejected; SDM with time fixed effects is adopted.
SDM with spatial and time fixed-effects v.s. SDM with random-effects	80.91	0.0000	$H_0: \mathrm{E}(x_{it}, \mu_i) = 0$ The null hypothesis (random-effects model) is rejected; SDM with spatial and time fixed effects is adopted.

4.4 Spatial Durbin model analysis results

Table 7 presents the estimation results of four Spatial Durbin Models (SDM) under different specifications, namely spatial fixed effects, time fixed effects, spatial and time fixed effects, and random effects. As indicated in the previous Hausman test results, Model 9 (SDM with spatial fixed effects) and Model 12 (SDM with random effects) did not provide relatively robust estimations. Therefore, these two models were excluded from further consideration, and the focus of the analysis was placed on the comparison between Model 10 (SDM with time fixed effects) and Model 11 (SDM with spatial and time fixed effects).

In terms of estimation methodology, this study employs Maximum Likelihood Estimation (MLE) and evaluates the overall performance of the models using three model fit criteria: Log Likelihood (LL), the Akaike Information Criterion (AIC), and the Schwarz Bayesian Information Criterion (SBC or BIC). Theoretically, the

optimal model should simultaneously exhibit a higher log-likelihood value and lower AIC and BIC values, indicating a better balance between goodness of fit and model parsimony.

The comparison results show that Model 11 (SDM with spatial and time fixed effects) outperforms Model 10 across all three fit indicators. Specifically, Model 11 has a significantly higher log-likelihood value than Model 10, while its AIC and BIC values are relatively lower, demonstrating superior explanatory power and model efficiency. Notably, the spatial autoregressive parameter ρ in Model 10 does not reach statistical significance, further weakening its applicability. Based on these findings, Model 11 is ultimately selected as the primary estimation model for subsequent empirical analysis.

In the estimation results of Model 11, the spatial lag coefficient is positive and statistically significant, indicating a strong positive spatial autocorrelation in the distribution of employment across Taiwan's counties and cities. In other words, an increase in employment in neighboring regions contributes to the growth of local employment, reflecting a clear regional complementarity and interdependence of employment activities in geographic space. This finding is consistent with Tobler's First Law of Geography, which posits that "near things are more related than distant things."

In sum, Model 11 (SDM with spatial and time fixed effects) not only demonstrates superior performance in terms of statistical fit but also effectively captures the spatial interactions of employment distribution among Taiwan's counties and cities. Accordingly, Model 11 is established as the empirical foundation for subsequent effect decomposition and policy recommendations in this study.

Table 7: Spatial Durbin model analysis results

Variables	Model 9 SDM with spatial fixed-effects		Model 10 SDM with time fixed-effects		Model 11 SDM with spatial and time fixed-effects		Model 12 SDM with random-effects	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
GGE	0.000	0.001	0.031***	0.004	-0.001	0.001	0.000	0.001
EDE	0.002***	0.000	-0.011***	0.002	0.002***	0.000	0.002***	0.000
ESCE	0.007***	0.000	0.027***	0.001	0.008***	0.001	0.008***	0.000
SWE	0.003***	0.001	-0.024***	0.002	0.003***	0.001	0.002***	0.001
CEE	0.000	0.001	0.000	0.004	0.000	0.001	0.000	0.001
RPE	0.011***	0.001	0.046***	0.003	0.011***	0.001	0.011***	0.001
W×GGE	-0.006***	0.001	-0.072***	0.007	-0.009***	0.002	-0.006***	0.001
W×EDE	0.000	0.001	0.015***	0.003	0.001	0.001	0.000	0.001
W×ESCE	-0.004***	0.001	0.017***	0.003	0.001	0.001	-0.004***	0.001
W×SWE	-0.003***	0.001	0.028***	0.004	-0.003**	0.001	-0.003***	0.001
W×CEE	0.009***	0.002	-0.015*	0.008	0.008***	0.002	0.009***	0.002
W×RPE	-0.003*	0.001	0.029***	0.005	0.001	0.002	-0.003*	0.001
Constant							121.834	71.266
n		528		528		528		528
Spatial ρ	0.609***	0.036	-0.091	0.085	0.385***	0.050	0.599***	0.036
within R^2	0.7892		0.4729		0.7568		0.7892	
between R^2	0.889		0.9869		0.8795		0.8478	
overall R^2	0.8581		0.9431		0.8406		0.8308	
Log-likelihood	-2383.883		-3174.198		-2368.220		-2490.087	
AIC	4795.766		6376.395		4764.441		5012.174	
BIC	4855.534		6436.162		4824.208		5080.479	

Note: * p<0.05; ** p<0.01; *** p<0.001

TWD: New Taiwan dollar (equal to USD 0.030). SDM: Spatial Durbin model. Coef.:Coefficient Std. Err.: Standard error. GGE = General Government Expenditure (million NTD); EDE = Economic Development Expenditure (million NTD); EESC = Education, Science, and Culture Expenditure (million NTD); SWE = Social Welfare Expenditure (million NTD); CEE = Community Development and Environmental Protection Expenditure (million NTD); RPE = Retirement and Pension Expenditure (million NTD).

4.5 Decomposition results of the SDM with spatial and time fixed effects

LeSage and Pace (2009) argue that because the Spatial Durbin Model (SDM) incorporates spatial lags of both the dependent and independent variables, interpreting results solely based on regression coefficients cannot accurately reflect the true marginal effects of each variable. This bias mainly arises from the "feedback effects" inherent in spatial models, whereby changes in an explanatory variable may influence the dependent variable in neighboring regions and subsequently feed back into the local region. Such mechanisms create a gap between parameter estimates and actual effects. Therefore, the proper interpretation requires decomposing the effects estimated by the SDM into three components: direct effects, indirect effects (i.e., spatial spillover effects), and total effects (LeSage & Pace, 2009; Elhorst, 2010).

Following the method proposed by Elhorst (2010), this study decomposes the effects of the SDM with spatial and time fixed effects, and the results are reported in Table 8.

The analysis shows that different categories of fiscal expenditure exert differentiated impacts on employment. First, general government expenditure (GGE) exhibits a significantly negative direct effect (coefficient = –0.002, $p<0.05$) and a significantly negative indirect effect (coefficient = –0.012, $p<0.001$), resulting in a total effect of –0.015 ($p<0.001$). This indicates that increases in general administrative spending not only fail to promote employment but instead suppress it locally as well as in neighboring regions, suggesting that such expenditures lack direct stimulus to the labor market.

In contrast, economic development expenditure (EDE) has a significant positive impact on employment. Its direct effect is 0.002 ($p<0.001$), the indirect effect is 0.002 ($p<0.05$), and the total effect reaches 0.004 ($p<0.001$), indicating that this type of expenditure can expand local labor demand while simultaneously generating positive spillovers to surrounding counties. Education, science, and culture expenditure (EESC) demonstrates the most pronounced positive effects, with a direct effect as high as 0.009 ($p<0.001$), an indirect effect of 0.005 ($p<0.001$), and a total effect of 0.014 ($p<0.001$). This shows that educational and cultural investments deliver sustained and broad positive benefits for job creation.

The impact of social welfare expenditure (SWE) is more complex. Its direct effect is significantly positive (coefficient = 0.002, $p<0.001$), while its indirect effect is significantly negative (coefficient = –0.002, $p<0.05$), leading to an overall insignificant total effect (coefficient ≈ 0). This result implies that although welfare spending enhances stability in the local labor market, welfare policies in neighboring regions may create an attraction effect or competition for resources, thereby weakening the positive spillover.

For community development and environmental protection expenditure (CEE), the direct effect is not significant, but the indirect effect is significantly positive (coefficient = 0.010, $p<0.001$), which in turn results in a significantly positive total effect of 0.011 ($p<0.001$). This suggests that the influence of community and environmental expenditures operates mainly through cross-regional spillovers, underscoring the externalities generated by infrastructure and environmental improvements.

Finally, retirement and pension expenditure (RPE) shows stable and positive effects on employment. The direct effect is 0.012 ($p<0.001$), the indirect effect is 0.007 ($p<0.01$), and the total effect is 0.018 ($p<0.001$). This indicates that pension-related expenditures not only strengthen local employment by stabilizing the labor market but also generate positive spillover effects across regions.

Overall, the decomposition results highlight the differentiated mechanisms by which various categories of fiscal expenditure influence employment. Economic development and education-related spending exert consistent positive impacts both locally and in neighboring regions; general government expenditure exerts negative effects; social welfare spending presents a contradictory “positive local but negative

neighboring" pattern; community and environmental spending mainly influence employment through externalities; and retirement and pension expenditures demonstrate both local and spillover positive effects. These findings not only confirm the importance of spatial effects but also suggest that policy evaluation must be conducted within the broader context of regional interdependencies.

Table 8: Direct, indirect, and total effects of SDM with spatial and time fixed-effects

Variables	Direct Effect		Indirect Effect		Total Effect	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
GGE	-0.002*	0.001	-0.012***	0.002	-0.015***	0.003
EDE	0.002***	0.000	0.002*	0.001	0.004***	0.001
ESCE	0.009***	0.001	0.005***	0.001	0.014***	0.002
SWE	0.002***	0.000	-0.002*	0.001	0.000	0.001
CEE	0.001	0.001	0.010***	0.002	0.011***	0.003
RPE	0.012***	0.001	0.007**	0.003	0.018***	0.003

Note: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

TWD: New Taiwan dollar (equal to USD 0.030). Coef.:Coefficient. Std. Err.: Standard error.

GGE = General Government Expenditure (million NTD); EDE = Economic Development Expenditure (million NTD); EESC = Education, Science, and Culture Expenditure (million NTD); SWE = Social Welfare Expenditure (million NTD); CEE = Community Development and Environmental Protection Expenditure (million NTD); RPE = Retirement and Pension Expenditure (million NTD).

5. Conclusion and Suggestions

5.1 Conclusion

This study employs panel data from 22 counties and cities in Taiwan spanning the period 2000–2023 to examine the impact of local fiscal expenditure on employment, with a particular focus on the presence of spatial spillover effects. A spatial weight matrix was first constructed to reflect geographical adjacency among counties and cities, and the Spatial Durbin Model (SDM) was selected as the primary analytical framework. Through a series of Wald tests and likelihood-ratio tests, the SDM was found to be more appropriate than the Spatial Lag Model (SLM) and the Spatial Error Model (SEM), as the coefficients of spatially lagged independent variables were significantly different from zero. This indicates that traditional models would fail to fully capture the true effects of fiscal expenditure on employment. In addition, Hausman test results revealed that when time or both spatial and temporal heterogeneity are considered, fixed-effects models are more suitable. Consequently, the SDM with spatial and time fixed effects was established as the final core model. The model estimation and decomposition analyses reveal heterogeneous effects of different categories of fiscal expenditure on employment. Expenditure on education, science, and culture, as well as economic development, demonstrated consistently positive direct and indirect effects, indicating that investments in human capital and industrial development not only stimulate local employment but also promote job growth in neighboring regions, generating clear regional diffusion effects.

Retirement and pension expenditure also showed positive impacts, suggesting that social security spending supports employment by stabilizing labor markets and improving household income. In contrast, general government expenditure displayed significant negative effects, implying that such spending lacks direct contributions to job creation and may even crowd out productive expenditures, thereby suppressing labor demand. The influence of social welfare expenditure was more complex: while it exhibited positive effects locally, it produced negative spillovers in neighboring areas, suggesting that welfare policies may trigger cross-regional migration of people and resources, which in turn undermines overall employment outcomes. Community development and environmental protection expenditure, although not significant in its local effects, showed positive spillover effects, suggesting that such investments primarily create indirect employment benefits through cross-regional infrastructure and environmental improvements.

Overall, the results of this study confirm the high spatial interdependence of employment across Taiwan's counties and cities and highlight the differentiated employment effects of various categories of fiscal expenditure at both the local and neighboring levels. This implies that local governments should not only focus on the effects within their own jurisdictions but also account for interregional interactions when formulating fiscal policies. Coordinated investments in education, economic development, and social security can enhance local labor absorption capacity while also promoting balanced regional development. Conversely, neglecting spatial spillover effects may result in misallocation of resources and diminished overall policy effectiveness.

By applying spatial econometric analysis, this study provides empirical evidence that local fiscal expenditure significantly influences employment and that different types of expenditure generate asymmetric spatial effects. These findings fill an important gap in the literature on Taiwan's regional labor markets and offer valuable insights for local governments in designing and adjusting fiscal policies. They underscore the necessity of considering both local needs and interregional linkages in policy planning to effectively enhance employment levels and promote overall regional development.

5.2 Policy suggestions

Based on the empirical findings of this study, local fiscal expenditures exert significantly different effects on employment across categories, with both local impacts and spatial spillover effects. These results not only reveal the heterogeneity of fiscal policy implementation across Taiwan's counties and cities but also highlight the importance of interregional interactions. Accordingly, this study proposes several policy implications.

First, education, science, and culture expenditure, along with economic development expenditure, demonstrate the strongest positive impacts on employment, producing both local and neighboring effects. This suggests that sustained investment in education, research and development, and industrial

upgrading can strengthen the quality of the local labor force and enhance industrial competitiveness, while simultaneously driving employment growth in surrounding areas. Therefore, both central and local governments should prioritize the stability and growth of education- and industry-related spending in fiscal planning, and actively encourage cross-county cooperation to amplify the spatial spillover benefits of such investments.

Second, retirement and pension expenditure also shows stable positive effects on employment, indicating that a sound social security system not only improves household consumption capacity but also supports employment by stabilizing aggregate demand. It is thus recommended that the government continue to enhance social insurance and pension systems, while ensuring fiscal balance across regions to avoid uneven employment support effects caused by disparities in financial resources.

In contrast, general government expenditure has a significant negative impact on employment, reflecting its limited direct contribution to the labor market and its potential crowding-out effect on productive expenditures. Therefore, policymakers should strengthen efficiency reviews of administrative spending, reduce redundant or duplicative expenditures, and redirect limited fiscal resources toward categories that can directly or indirectly foster employment.

Furthermore, social welfare expenditure exhibits a "local positive but neighboring negative" effect, suggesting that differences in welfare policies across regions may create externalities through competition for resources and labor migration. This indicates that welfare policy design should not be confined to the perspective of individual counties but should instead incorporate interregional coordination and central government subsidy mechanisms to mitigate regional disparities in employment outcomes caused by welfare gaps.

Lastly, community development and environmental protection expenditure does not generate significant local employment effects, but its positive spillover impact suggests that the benefits of infrastructure and environmental improvements often transcend administrative boundaries. This underscores the need for governments to adopt a regional governance perspective and foster cross-county collaboration in major public works and environmental initiatives. Integrated planning and resource sharing can maximize the broader social and economic benefits of such investments.

In conclusion, local governments should avoid focusing narrowly on short-term, within-county effects when designing fiscal policies. Instead, policy impacts must be evaluated within the broader context of regional interactions. Only through interregional coordination, appropriate central–local division of responsibilities, and optimized resource allocation can employment growth be sustained and balanced regional development achieved.

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