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Article

Public governance, public investment and regional economic growth: Evidence from Vietnam

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Abstract: The article provides evidence on the effect of local public governance on the impact of public investment on local and regional economic growth, using spatial and regional logic. The research uses the spatial Durbin model and produces a panel data set that was conducted on 63 provinces of Vietnam from 2006 to 2022. Based on the interaction between public governance and public investment, the main findings indicate that their interaction plays an important role in adjusting the effects of public investment and public governance on economic growth not only in the locality but also spillover to neighboring localities in both the short and long terms. It suggests that local public governance not only hampers the impact of local public investment on local economic growth but also has spillover effects on the growth of neighboring provinces or regions in Vietnam. Additionally, the results of detailed analysis of PCI component indicators show that many aspects of local public governance are hindering local economic growth but contributing to promoting neighboring localities economic growth. Or, it has no effect the locality but promote or hinder the regional economic growth. The findings in this study implies that authorities of localities need to be cautious when using resources to improve the various aspects of public governance when designing strategies to enhance the quality of local public governance. It also suggests that this spillover effect is a crucial factor in advocating for more redistributive fiscal policies and regional governance policies aimed at reducing economic disparities caused by territorial boundaries. Therefore, authorities should prioritize regional cooperation strategies in their decisions regarding public governance and public capital allocation.

Keywords: local public governance; regional economic growth; local public investment; spillover effect; spatial economic

1. Introduction

The argument begins with the premise that public investment influences the geographical distribution of economic activities, and the resulting effects can spread across regional borders (Kemmerling and Stephan, 2008; Ottaviano, 2008; Rodríguez-Pose et al., 2012). Investments in public infrastructure enhance market access, reduce transaction costs, and stimulate higher private investment (Martin, 1999; Martin and Rogers, 1995), thereby fostering regional and national economic growth as well as convergence. Furthermore, infrastructure development shapes the spatial structure of economic regions based on the hypothesis of redistributing distribution areas (Hanson, 2001; Hanson, 1986; Krugman, 1991). Moreover, public investment allocation towards research and development and human capital expenditure contributes to enhancing labor productivity and capital efficiency, thereby promoting local and regional economic growth within the context of migration and technology integration. However, there is a risk of the crowding-out effect of public investment on private

investment, potentially resulting in a negative impact on growth (Andrade and Duarte, 2016; Aschauer, 1989a; Bahal et al., 2018).

It aligns with another interconnected argument in economics concerning institutions and politics, it is believed that political decisions play a crucial role in determining the spatial allocation of public resources (Rodríguez-Pose et al., 2012). Public capital expenditure activities are often a direct result of the government's decisions and policy maker's visions rather than responses to pure social welfare needs or economic efficiency (Cadot et al., 2006; Castells and Solé-Ollé, 2005; Yamano and Ohkawara, 2000). This is influenced by economic activities and political institutional factors, which can shape growth patterns. Furthermore, local governments often strategize development initiatives to enhance local competitiveness, aiming to amplify the positive impacts of public investment on economic growth through collaboration with the private sector.

Furthermore, the allocation of public investment into infrastructure projects and public service providers is greatly influenced by political decisions and local institutions. It is evident that the efficiency of public investment is heavily dependent on institutional quality (Dabla-Norris et al., 2012; Gupta et al., 2016). Institutional factors, which encompass the entire process of a public investment project including project selection, implementation, management, and quality assessment, are crucial in determining the effectiveness of the project. (Dabla-Norris et al., 2012). As a result, it allows for the distortion of the effects of public investment on economic growth. (Gupta et al., 2016). Furthermore, numerous past empirical findings indicate that local governance has a significant impact on territorial economic development (Ganau, 2017; Rodríguez-Pose et al., 2012). Localities in close proximity can collaborate on managing public infrastructure and resources through institutional cooperation, ensuring efficient investment and minimizing redundancy and waste of public resources.

A proposed idea is to study how institutions and political factors affect the relationship between public investment and economic growth, especially when considering how things are connected in different places. The idea revolves around investigating whether local government affects how public investment impacts local economic growth and nearby areas. It also considers whether the effects of local government on public investment's impact on economic growth spread to neighboring places.

To address these questions, a study is needed, and Vietnam is a suitable candidate. Vietnam is a developing country that has implemented numerous reform programs, and its economic growth largely relies on accumulating various factors. In Vietnam, the flow of investment capital is crucial for sustaining and enhancing growth. Public investment, in particular, serves as a vital source, especially for maintaining connections between different areas as part of regional development strategies, thanks to its impact on investment efficiency. However, there are many signs indicating that the efficiency of public investment has been declining for over a decade. This suggests potential disruptions in connections between different areas within the country (localities) and between regions. The way investment capital is allocated lacks a clear priority strategy, with funds spread across too many areas. As a result, only around 20% of projects managed by the central government were completed between 2000

and 2014 (The World Bank, 2018). Additionally, the total amount of state budget allocated can only meet less than 50% of the total demand for investment projects approved by both central and local governments from 2013 to 2015 (The World Bank, 2018). Despite the sharp increase in the proportion of public investment to GDP since the Doi Moi reforms in 1986, reaching up to 40% during 2006–2010 and peaking at 46.52% in 2007, the national average growth rate has only fluctuated around 6%–8% (The World Bank, 2018). Wastefulness, poor project quality, and slow disbursement of public investment funds result in delays in project implementation, which in turn hampers the positive effects of public investment (VCCI and Fulbright, 2022). Weak institutional frameworks contribute to poor connections between different regions within the country and among neighboring regions. Additionally, localities tend to prioritize enhancing their own competitiveness through competitive strategies rather than collaborating, sharing, and managing public infrastructure to stimulate growth. These outcomes lead to a slowdown in growth, which negatively impacts the economy. The root cause may lie in a lack of deep understanding of how institutions affect the efficiency of public investment, particularly regarding the influence of public governance on the impact of public investment on economic growth.

This article focuses on how public governance, which represents the rules and systems in place, influences the relationship between public investment and economic growth in Vietnam's 63 provinces and cities from 2006 to 2022, looking at this from a spatial and regional viewpoint.

In this study, spatial econometrics models are used to analyze how public governance affects public investment and economic growth in Vietnam's provinces and cities. Specifically, the focus is on understanding how public governance influences the impact of public investment on economic growth in both its own area and neighboring areas. The main goal is to understand how public governance helps adjust the connection between public investment and regional economic growth. This research is crucial for creating policies that can reduce economic disparities caused by territorial differences and promote equality.

The paper is organized as follows: In Part 2, there are 3 subsections. It gives an overview of the theories and studies that explain how local public governance and local public investments affect local and regional economic growth. Section 2.1 focuses on analyzing how local public investment influences local and regional economic growth. It also looks at how public investments in one area can affect economic growth in nearby areas due to spatial economic connections.

In Part 3, the next subsection directly discusses the concept and measurement of local public governance. It examines how local public governance moderates the relationship between local public investment and local and regional economic growth. It also discusses its influence on regional economic growth. The final subsection discusses the relevance, consistency, necessity, and practical significance of studying this topic in the context of Vietnam.

Part 3 explains the research methodology, including the econometric model used in the study, while Part 4 presents the main results and discussion. The conclusion summarizes the findings, discusses important policy implications, acknowledges limitations of the analysis, and suggests new research ideas.

2. Public governance, public investment and regional economic growth—The spatial linkages: An overview

2.1. Public investment and regional economic growth: Spillover effect?

Public investment, tracing back to Keynes, has been characterized as an economic stabilizer (Musgrave, 1959), a catalyst for development and growth (Hirschman, 1958) and a means for redistributing national wealth and income among various groups and geographical regions (Oates, 1972). As seen in literature, public investment can have effects on the economy from both the supply and demand sides. On the supply side, increasing public investment capital not only directly increases total supply but also indirectly enhances the quality of human resources and fosters technological innovations, consequently amplifying the overall economic supply. Solow (1956) argued that public investment and private investment are seen as complementary to each other. According to this theory, the increase in public capital enhances aggregate output and increases the productivity of all other factors including labour. If the labour market is competitive and the supply of labour is inelastic, an increase in labour productivity leads to an increase in wages. In the long run, economies with higher rates of public investment will have greater levels of productivity per worker. In the short and medium term, economies with a higher ratio of public investment capital will have a higher economic growth rate (in the case of labour productivity is stable in the long term). However, public investment can crowd out private investment. This displacement occurs when public investment is funded through high future taxes and elevated interest rates, when the public sector produces goods directly competing with private goods, or when public consumption expenditures compete with other private investments (Erenburg and Wohar, 1995). Crowding-out effects become apparent when distortions in the public sector are excessively large. To fund an increase in public investment, the government may require more physical capital, leading to higher interest rates and, consequently, restricting the private sector's access to capital markets. As a result, economic growth may decline due to a reduction in private-sector investment.

On the demand side, according to Keynesian principles, when investment increases, it boosts overall demand as long as other factors stay the same. Changes in both supply and demand affect the rate of economic growth, and changes in investment capital are a major factor in these shifts. Public spending on things like infrastructure, healthcare, public health, and education and training also plays a role. Infrastructure projects, especially, can lower costs for businesses and attract more production, which helps the economy grow (Egger and Falkinger, 2006; Haughwout, 2002).

Furthermore, the impact of public investment on growth extends beyond geographical boundaries and reaches neighboring economic areas due to the interdependence between regions and localities. Indeed, according to (Aschauer, 1989b, 1989a), public investment can stimulate private investment by providing the essential infrastructure for economic activities, which is a fundamental factor in explaining variations in levels of growth and spatial economic. Therefore, it leads to enhanced capital productivity and promotes economic growth (Cook and Munnell, 1990; Munnell, 1990). In reality, public funds are often allocated to infrastructure

projects and improving the quality of labor through investments in education and health. These investments impact all economic activities within a given area. Infrastructure projects also shape the spatial structure of economic regions, based on the idea of redistributing resources for development (Hanson, 2001; Hanson, 1986; Krugman, 1991). Public infrastructure plays a vital role in attracting industries from other countries or regions. This leads to projects improving infrastructure between regions, which changes how regional economies are organized and reduces transaction costs (Martin, 1999; Martin and Rogers, 1995). Moreover, when there's more public investment in infrastructure, it tends to boost the productivity of other factors like labor and private capital. This helps reduce the cost of producing each unit (Cohen and Paul, 2004; Teruel and Kuroda, 2005). When public investment in education and health is combined with investments in infrastructure, it improves the quality of labor resources. Over time, this increases the economy's production capacity. These changes can lead to shifts in regional economic growth and inequalities in spatial economics.

It's evident that local public investment has a big impact on shaping regional economic growth and disparities. Numerous empirical studies support the notion that public investment has a positive and strong effect on regional economic growth (Aschauer, 1989b; Cook and Munnell, 1990; Costa-i-Font and Rodriguez-Oreggia, 2005; Kamps, 2005; Kemmerling and Stephan, 2008; Rodríguez-Pose et al., 2012; Safae and Radouane, 2023; Van Luong et al., 2020; Yamano and Ohkawara, 2000; Zhang et al., 2021). The findings mainly show that public investment affects how economic activities are spread out, and these effects can move across regional borders (Aschauer, 1989b; Cook and Munnell, 1990; Kamps, 2005; Rodríguez-Pose et al., 2012; Safae and Radouane, 2023). Changes in how economic activities are spread out often happen because of public investment, which impacts local economic growth and even entire regions (Costa-i-Font and Rodriguez-Oreggia, 2005; Rodríguez-Pose et al., 2012; Safae and Radouane, 2023).

Notably, Rodríguez-Pose et al. (2012) suggested using data on public investment spending in Greek districts from 1997 to 2007. They aimed to understand how public investment affects growth in Greek districts and its spill-over effects on nearby areas. The results showed that public investment had a positive impact on regional economic growth and significant spill-over effects on neighboring areas. However, the impact of public investment varies depending on the type, with investments in education and infrastructure having the highest impact. Zhang et al. (2021) studied the effects of different types of public infrastructure investment on regional economic growth in the Duong Tu River Economic Zone in China from 2003 to 2016, involving 131 cities. They found that investments in different types of public infrastructure have distinct spatial impacts on regional economic growth. Specifically, investment in energy infrastructure significantly boosts overall economic growth, both locally and in neighboring regions. Transport infrastructure investment mainly stimulates local economic growth but has a limited impact on surrounding areas. Conversely, water-related infrastructure investment limits local economic growth but promotes growth in neighboring regions. Safae and Radouane (2023) recently studied how public investment affects economic growth in Morocco using regional and spatial analysis. They found that public investment has a limited impact on regional growth, although it still plays a significant role in local growth. This suggests that public investment

doesn't strongly contribute to regional economic prosperity due to weak spatial effects. In Vietnam, Van Luong et al. (2020) researched the impact of public investment on economic growth in mountainous areas from 2000 to 2018. They found that public investment has a strong impact on regional economic growth in the short term but weakens over time due to declining investment efficiency. However, their study didn't consider the spatial dependence between provinces, which can lead to biased results in regional growth assessments. Overall, studies are cautious about considering spatial dependence when assessing the impact of public investment on local and regional economic development.

Furthermore, many experiments also show that the impact of public investment on economic growth is significantly contingent on institutional quality, including the control of domestic corruption (Haque and Kneller, 2015). The effectiveness of public investment in fostering growth may be constrained by the quality of institutions, as indicated by studies such as Keefer and Knack (2007) and Dabla-Norris et al. (2012). Keefer and Knack (2007) observe an increase in public investment levels with declining institutional quality, suggesting that such investments may prove less effective in countries where institutions foster private rent-seeking by public officials. Barhoumi et al. (2018) echo this sentiment, noting that in countries with low institutional quality, governments may utilize capital expenditure for rent-seeking purposes, diminishing the impact of public investment. Dabla-Norris et al. (2012) demonstrate how the efficacy of public investment hinges on institutional factors throughout the entire lifecycle of a public investment project, encompassing project selection, implementation, management, and post-audit review. Effective project selection involves choosing investments with the highest economic and social benefits, requiring the establishment of capable institutions for implementation. Gupta et al. (2016) further show that the quality of project selection, management, evaluation, and the legal and operational framework all influence the impact of public investment on economic growth. However, distortions may arise, leading to project selections based on benefits to officials rather than those with a superior combination of price and quality, or reliance on public programs generating more illicit income for politicians than those enhancing living conditions. These distortions diminish the impact of public investment on growth, emphasizing the crucial need for effective institutional capacity (Grigoli and Mills, 2014). In the subsequent subsection, Part 2.2 clarifies the role of institutions, particularly local public governance, in influencing the connection between public investment and local as well as regional economic growth.

2.2. Local public governance: The role?

Public governance is a multidimensional concept, including three main aspects: political institutions (the process by which governments are selected, governed and replaced); government effectiveness (the government's ability to form and implement policies); and the legal framework (people's reactions and the state of institutions that govern the economic and social interactions between them)(Acemoglu and Robinson, 2008; Kaufmann et al., 2002, 2003). Essentially, public governance can be distilled into the exercise of political power in managing a country's affairs (The World Bank, 1992). The OECD (2001) asserts that a country's economic performance over a period

is significantly influenced by its governance effectiveness, including the political environment, institutions, and legal framework. Consequently, "good governance will enhance democracy and human rights, promote economic prosperity and social cohesion, alleviate hunger and reduce poverty, strengthen environmental protection, and enable the efficient use of natural resources and increase confidence in government and public governance" (Tarschys, 2001).

Public governance includes both local and national governance. In this article, the focus is mainly on the effects of local public governance. So, when "Public Governance" is mentioned, it's similar to referring to "Local Governance" in this context. Based on theories about governance and public governance, the concept of local governance emerged in the 1960s. It's associated with the decentralization process occurring in many countries worldwide (Baland et al., 2010; Bardhan and Mookherjee, 2006). Local governance aims to establish a closer connection between the government and residents, allowing citizens to participate more in local affairs. This helps to increase the accountability of local leaders in making and carrying out decisions and policies (The World Bank, 1992). Thus, local governance, as described above, guides the local socio-economic development process by: (i) setting strategic goals for local economic development, creating development plans, managing local tasks, and efficiently utilizing local resources; (ii) enforcing laws and implementing decisions of the central government at the local level, representing the interests and welfare of residents, and encouraging community involvement in state affairs; (iii) ensuring the well-being of local residents, promoting fairness and social equality within the community (Baland et al., 2010; Bardhan and Mookherjee, 2006; The World Bank, 1992). Therefore, effective local public governance is crucial for development and economic growth. This includes: (i) holding local government accountable; (ii) preventing and reducing corruption; (iii) efficiently using resources to support local socio-economic development.

Firstly, when local government becomes more responsible, it boosts local competitiveness, attracts private sector investment, and drives economic growth.

Secondly, good local governance improves transparency and reduces corruption, cutting down on unofficial costs. This leads to more efficient public investment projects, increased private sector involvement, and faster economic growth.

Thirdly, good local governance ensures effective use of resources, supporting local socio-economic development and enhancing local competitiveness. By removing legal barriers and reducing transaction costs for local businesses, it gives the locality and its businesses a competitive edge, further promoting economic growth and development.

Both theory and practice confirm the crucial role of public governance in local economic growth and development. Many studies have shown that effective local governance leads to strong economic growth (Adzima and Baita, 2019; Baland et al., 2010; Johansson et al., 2001; Mahran, 2023; Shah, 2006; Smith, 2007). However, there are not many experiments that assess how local government affects regional economic growth. One rare study by Johansson et al. (2001) suggests that local infrastructure, institutions, and policies help the region grow from within. This means that local or regional success comes from competing based on advantages that develop over time. Also, most studies on public governance often ignore how nearby areas affect each

other economically—spatial dependence of economic. Only a few studies have managed to do this while looking into this topic. Seldadyo et al. (2010) conducted a study that found a positive link between governance in one country and governance in its neighboring countries. This means that a change in one country's governance doesn't just affect its level of governance but also influences neighboring countries. Similarly, a recent study by Mahran (2023) discovered that public governance has a significant impact on economic growth when considering how countries affect each other. This means that improvements in public governance in one country can also boost economic growth in neighboring countries. Even though these studies focus on national-level governance, they highlight that efforts to improve economic competitiveness through governance policies are important both nationally and locally.

Moreover, there are very few studies that examine how local public governance affects the impact of public investment on regional economic growth. Most studies so far have only looked at how public administration can improve the effects of public investment on economic growth within a region, such as Adenuga and Evbuomwan (2013), Bah and Kpognon (2021), Bon (2019), Dzhumashev (2014), Haque and Kneller (2015), Miyamoto et al. (2020), Rodríguez-Pose et al. (2012), Safdar et al. (2022), Su and Nguyen (2021).

While some studies focus on the role of governance in stimulating private investment to generate economic efficiency (Bah and Kpognon, 2021; Bon, 2019; Everhart et al., 2003) others focus on public investment through government spending (Cooray, 2009; Dinh Thanh et al., 2020; Su and Bui, 2017). Most of the experiments used regular econometric models that ignore the spatial dependence of observations such as ECM model and the PMG (Panel Mean Group) (Bah and Kpognon, 2021), GMM model (Bon, 2019; Dinh Thanh et al., 2020; Su and Bui, 2017). A standout study by Bah and Kpognon (2021) findings underscores that political stability and the rule of law, as dimensions of institutional quality, amplify the positive impact of public investment on growth in ECOWAS countries. Consequently, enhancing governance quality and increasing public investment work in tandem to foster economic growth. Similarly, Dinh Thanh et al. (2020) show that effective governance, characterized by attributes like lower informal costs, increased transparency, and objective policies, proves pivotal in augmenting the impact of government spending on economic growth, especially through interactions with private sector investment. Further noteworthy findings emerge from studies like Su and Bui (2017) demonstrating that changes in public governance quality play a crucial role in enhancing the impact of government size on private investment, thereby contributing to improved economic growth. Dzhumashev (2014) highlights the interaction between corruption and state governance as a determinant of the effectiveness of public expenditure, with corruption positively impacting economic efficiency when the actual size of government surpasses an optimal level. Nguyen and van Dijk (2012) provided evidence that corruption can hamper economic growth by favouring the public sector over the private sector, and improving the quality of local public governance can help alleviate corruption and stimulate economic growth. Miyamoto et al. (2020) argue that stronger institutions for managing public investment, i.e., better infrastructure governance, are likely to reinforce the link between public investment and growth, and vice versa.

Indeed, existing research has predominantly concentrated on bilateral relationships, exploring connections such as public investment and growth, public governance and public investment, or public governance and growth. Studies considering multilateral relationships with various factors often lack an exploration of the contribution of public governance to the impact of public investment on growth. Limited research exists specifically assessing the role of public governance in the connection between public investment and economic growth. In instances where such research is conducted, as seen in studies by Adenuga and Evbuomwan (2013) and Miyamoto et al. (2020) it typically occurs at the national level, with a noticeable gap in studies at the local level. Most studies overlook the possibility of external effects and economic spatial dependence, except for Rodríguez-Pose et al. (2012) However, arguments from Johansson et al. (2001) and Mahran (2023) suggest that there could be external effects due to economic spatial dependence. Therefore, the main aim of this article is to assess how public administration influences the impact of public investment on economic growth within and between regions, considering economic periods and non-dependencies.

2.3. In the case of Vietnam

In Vietnam, public investment expenditure is a major result of infrastructure development for the economy. Throughout the transition to a market-oriented economy, the Vietnamese government has consistently pursued expansionary fiscal policies, augmenting public investment with the anticipation that it will positively impact economic activities, enhance overall productivity, and stimulate private sector investment. However, the magnitude of public investment by the Vietnamese Government tends to fluctuate, heavily contingent on the prevailing economic circumstances. During economic downturns and periods of high unemployment, public investment capital sees a significant surge; conversely, it is promptly reduced in the case of rapid economic growth and high inflation.

In recent years, informed by insights from economic experts, the Government of Vietnam has proactively undertaken policy reforms and improved the institutional environment to ensure more efficient and transparent utilization of public capital expenditure. This has led to an increased participation of the private sector in critical state projects, including the construction of highways and public-private partnership (PPP) projects in infrastructure and healthcare. Notably, the relatively high levels of public investment in most provinces and cities in Vietnam have exerted a substantial impact on local economic growth, with broader regional implications. For instance, the nexus of public investment and public governance in Ho Chi Minh City has the potential to influence the overall economic growth of the Southern economic region.

In this context, empirical studies are on the rise to gauge the impact of public investments and their influence. However, the obtained results lack certainty. As Vietnam continues to implement its territorial, economic, and social development programs, the effectiveness of their contribution to economic growth and the reduction of regional inequality and disparities remains a challenge, particularly in overcoming issues related to public governance. Addressing this concern and within the framework of regional cooperation, recognizing the spatial interdependence of regions becomes

crucial for regional economic development. This interdependence allows components within regions to interact, mitigating the impacts of inequality.

Hence, analyzing and examining spatial effects among regions becomes a critical topic. **Figure 1** provides a graphical representation of the correlation between public governance, public investment, and economic growth. The vertical axis represents the PCI score, where a higher PCI score indicates a greater level of public governance capacity in the locality. The horizontal axis represents the scale of public investment (logarithmically transformed), and the size of the circles denotes the magnitude of economic growth. The established correlation among public governance, public investment, and economic growth reveals that the circles tend to exhibit larger concentrations rather than being dispersed across most of the examined time points.

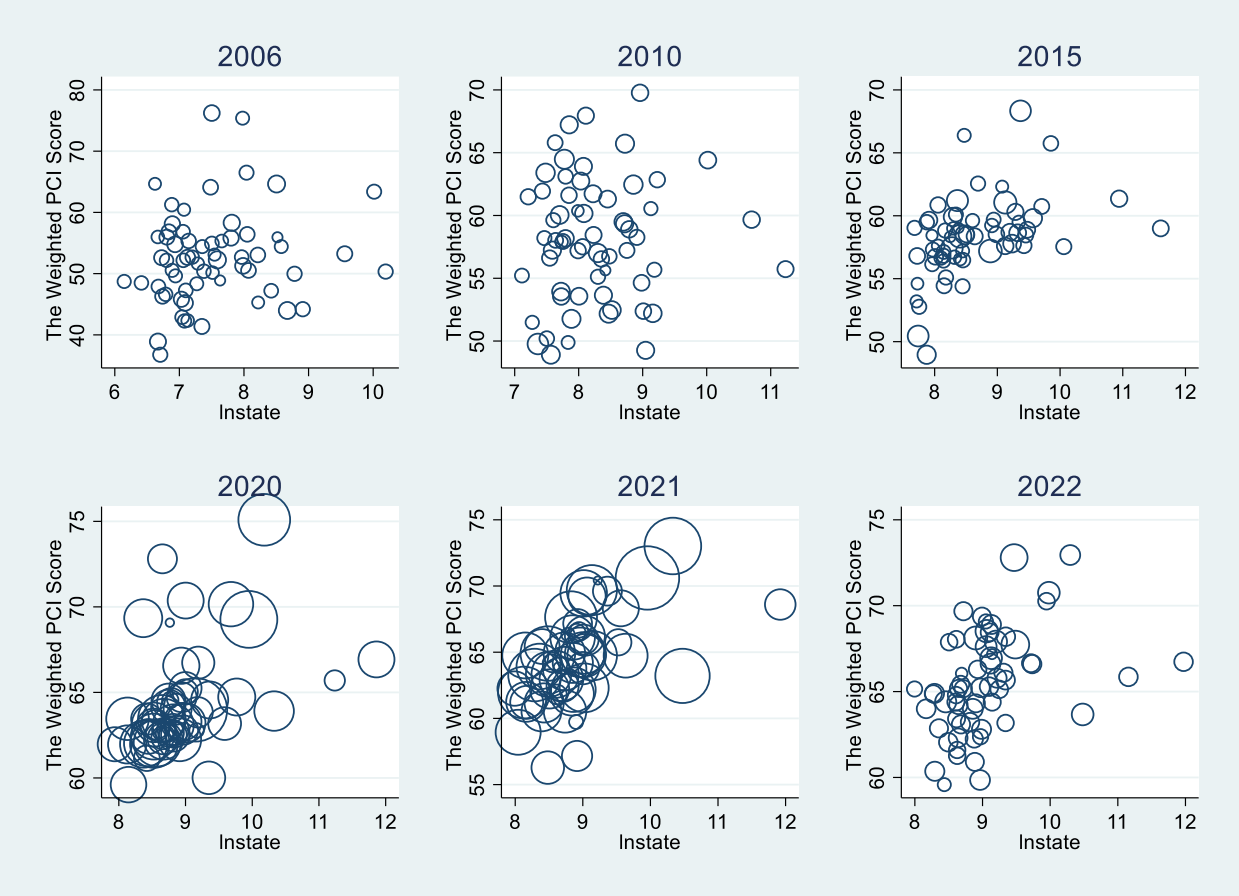

Figure 1. The correlation between public governance, public investment, and economic growth over the years.

Note: The vertical axis represents the score of the PCI, while the horizontal axis shows the magnitude of public investment after applying the logarithmic function. The size of the circle represents the size of economic growth.

Figure 2 depicts the changes in economic growth, highlighting the spatial dependence of growth as localities initiate in distinct colors and coalesce into clusters of the same color. The empirical examination of the role of public governance in shaping the relationship between public investment and growth will be conducted through modeling, with further elaboration provided in subsequent sections.

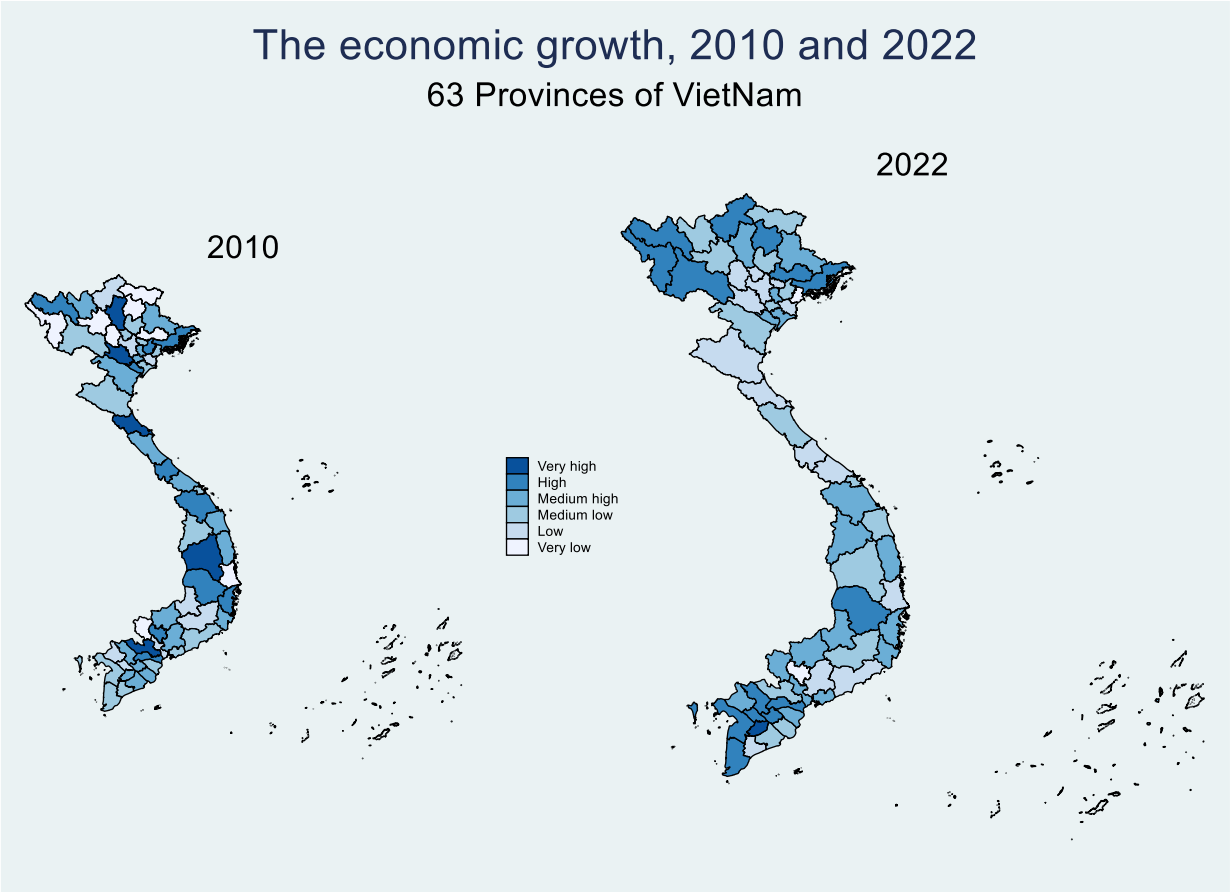

Figure 2. The economic growth over the years 2010, 2022, analyzed by spatial logic.
Note: Provinces/cities tend to be similar to each other and form clusters of each color.

Additionally, Vietnam's public governance model is built on decentralization mechanisms. Provinces and cities in Vietnam are considered local entities. Besides adhering to and implementing strategic directives from the central government, provincial governments have the authority to develop their methods of local governance based on unique local characteristics. This results in a diverse and independent range of public governance approaches among the country's 63 provinces/cities. Therefore, Vietnam is a suitable context for experimental examine in this article.

3. Methodology

3.1. The model framework

It based on the neoclassical growth model, formulated by Barro (1990) and further extended by Mankiw et al. (1992) incorporates public capital as an input into the production function. Equation (1) employs a Cobb-Douglas production function to extract the impacts of public investment on economic growth.

$$Y_{i,t} = A_{i,t} K_{i,t}^{\gamma} G_{i,t}^{\beta} L_{i,t}^{1-\gamma-\beta} e^{\mu} \quad (1)$$

- With $\gamma + \beta + (1 - \gamma - \beta) = 1$
- $Y_{i,t}$ is GRDP at time t of province/city *i*;
- $A_{i,t}$ total factor productivity - TFP,

- $K_{i,t}$ private investment capital,
- $L_{i,t}$ labour,
- $G_{i,t}$ public investment,
- e^{μ} estimation error,
- γ, β and $(1-\gamma-\beta)$ are the elasticity of production relative to domestic private capital, public capital and labour, respectively.
- i = 1, 2, 3, …, n (provinces)
- t = 1, 2, 3, …, t (times)

Using the assumption that total factor productivity is a function of public governance (Bah and Kpognon, 2021). the findings of Dabla-Norris et al. (2012) and Grigoli and Mills (2014) lead to the conclusion that enhancing the quality of governance contributes to increased efficiency in public investment. Consequently, improvements in productivity can be attributed to better governance practices and the more effective utilization of public investment. Accordingly, $A_{i,t} = A_0 e^{\theta GOV_{i,t}}$ với GOV with GOV representing the quality of public governance. Equation (1) will become:

$$Y_{i,t} = A_0 e^{\theta GOV_{i,t}} K_{i,t}^{\gamma} G_{i,t}^{\beta} L_{i,t}^{1-\gamma-\beta} e^{\mu} \quad (2)$$

Taking the natural logarithm of Equation (2) and converting (2) to log-linear equation form as follows:

$$\ln Y_{i,t} = \ln A_0 + \theta GOV_{i,t} + \gamma \ln K_{i,t} + \beta \ln G_{i,t} + (1-\gamma-\beta)\ln L_{i,t} + \mu_{i,t} \quad (3)$$

To focus more on the impacts in the relationship between public governance, public investment and economic growth, a brief simplified equation is as follows:

$$\Delta lnY_{i,t} = a_{i,t} + \beta_1 GOV_{i,t} + \beta_2 lnPUINV_{i,t} + \beta_3 X_{i,t} + e_{i,t} \quad (4)$$

In which, ΔlnY represents economic growth, PUINV represents *G*, government public investment, *X* is a set of other variables that affect economic growth, *e* represents invalid number of the model, i = 1, 2, 3, …, n (province), t = 1, 2, 3, …, T (time).

To better grasp the role of public governance in the relationship between public investment and economic growth, the article incorporates an interaction variable (Bah and Kpognon, 2021; Bon, 2019; Dinh Thanh et al., 2020; Su and Bui, 2017) represented as the combination of two variables: public governance and public investment, expressed as GOV × PUINV. The term interactive variables help determine if the relationship between dependent and independent variables changes depending on another independent variable (Jaccard et al., 1990). The estimated coefficients of the interaction variables serve as indicators of how the quality of public governance plays a role (complementary/reinforcing - positive sign or hindering - negative sign) in the impact of public investment on economic growth. A positive and statistically significant coefficient would imply that an increase in public investment, coupled with better public governance, will stimulate economic growth (Bon, 2019; Dinh Thanh et al., 2020).

$$\Delta lnY_{i,t} = a_{i,t} + \beta_1 GOV_{i,t} + \beta_2 lnPUINV_{i,t} + \beta_3 (GOV \times lnPUINV_{i,t}) + \beta_4 X_{i,t} + e_{i,t} \quad (5)$$

Essentially, public investment projects or public governance policies are implemented over several years, leading to both short-term and long-term impacts. This implies that the effects of investment or public governance transmission are distributed over time. For instance, an investment allocated by the government to build

public infrastructure or train human resources in locality *i* in year *t* will yield direct income effects for the private sector (enterprises) in locality *i* and neighboring localities in government *t* or in year *t* + 1. Furthermore, the government of locality *i* will receive direct income effects, such as tax revenue (corporate income tax) in year *t* + 1, with the possibility that neighboring localities will also benefit from these effects in year *t* + 1. Examples include highly skilled individuals moving from locality *i* to neighboring areas for work, or businesses expanding their production scale, even to neighboring regions, if the infrastructure development in the host locality meets their future growth needs, along with synchronized infrastructure with neighboring localities, fostering trade connections between the two regions. In addition, the complexities of economic fluctuations, development cycles, and different stages in the global development flow make it challenging to measure and assess this phenomenon. Moreover, local and regional characteristics and interdependencies exhibit spatial non-randomness. The spatial dependence of regions becomes a crucial factor in regional economic development (Krugman, 1998), allowing the constituents of these regions to interact, mitigating the depreciation of spatial inequality impacts. Addressing these challenges requires consideration of various econometric aspects, including (i) resistance to time variation, (ii) observation of short-term and long-term effects, and (iii) capturing spatial spillovers. Hence, the exploration of spatial effects dissemination between regions necessitates thorough analysis. Advancements in spatial econometrics Anselin (1988), Anselin (2022) and have furnished effective tools for studying regional economic spatial dependence, particularly in considering spatial correlation between economic regions. Notably, the spatial Durbin model (SDM) (LeSage, 2015; LeSage, 1999) encompasses both spatially dependent and spatially independent variables, facilitating the capture of spatial correlation effects of the independent variable on the dependent variable for robust and reliable estimates. Indeed, beyond the spatial lag factor of the dependent variable, its values can also be influenced by the independent variable values in neighboring observations. Moreover, the model can differentiate between direct effects (the influence of a specific explanatory variable on the dependent variable) and indirect effects, referred to as partial spillovers. The spatial impact estimation is expressed by the following equation:

$$\Delta lnY_{i,t} = \alpha_0 + \rho W \Delta lnY_{i,t-1} + \alpha_1 WGOV_{i,t} + \alpha_2 W lnPUINV_{i,t} + \alpha_3 \mathrm{W}(GOV_{i,t} \times lnPUINV_{i,t}) + \alpha_4 WX_{i,t} + \beta_1 GOV_{i,t} + \beta_2 lnPUINV_{i,t} + \beta_3 (GOV_{i,t} \times lnPUINV_{i,t}) + \beta_4 X_{i,t} + u_{i,t} + \tau_{i,t} + e_{i,t} \quad (6)$$

where:

$\Delta lnY_{i,t}$ indicates the economic growth of province *i* at time *t*;

W is the normalized element weight matrix for neighborliness;

$GOV_{i,t}$ is the public governance indicator of the province *i*, at time *t*;

$X_{i,t}$ is a list of the control variables;

u_i is a spatial specific effect controlling for time-invariant variables;

τ_tis a time-specific effect accounting for spatial-invariant variables;

The matrix *W*, an N × N spatial weights matrix, undergoes normalization such that the elements of each column sum up to one. This column normalization enables the measurement of the impact of each province on all other provinces (Elhorst, 2017; Elhorst and Elhorst, 2014). In the context of Vietnam, a neighborhood measure utilizing a population-weighted geographic distance matrix is employed. This includes

a row-standard weighting matrix calculated across provinces in K-Newest, based on the distance between provincial administrative centers (provincial capitals) (Baicker, 2005; Le Gallo and Ertur, 2003). K-Newest provinces are weighted by their population size as geographical units, considering that larger influence can occur in the case of people with similar demographic characteristics (in this study, the 63 nearest provinces were considered). This matrix type is preferred over continuous and adjacent types due to the presence of islands in the sample and the ability to select the same number of neighbors for each province (De Siano and D'Uva, 2014).

3.2. Data and measurement

This subsection provides details about the measurements and data sources used in this study (**Table 1**). The data for this article is sourced from two main sources: the General Statistics Office of Vietnam (GSO) and the Vietnam Chamber of Commerce and Industry (VCCI). The GSO provides databases related to growth, investment, and labor concepts, while VCCI provides databases related to public governance indicators. Since the public governance databases provided by VCCI began in 2006, this study focuses on the period from 2006 to 2022 to utilize the available data. Below is a detailed explanation of the measurements for each variable in the econometric model presented in Subsection 3.1.

Table 1. Description of measurement variables.

Signs	Description	Measurement and sources
Y	Real GDP per capital	Gross provincial nominal product per capita adjusted by provincial inflation (VND million), from the annual provincial Statistical Yearbook
GOV	Public governance	The PCI index and 9 subindex include: entry costs, access to land, transparency, time costs, informal charges, proactivity, business support policy, labour policy, and law & order, from the Vietnam's VCCI
PUINV	Public investment	Total government investment include local government investment and central government investment adjusted by provincial inflation (VND Billion), from the annual provincial Statistical Yearbook
PIINV	Private investment	Provincial domestic private investment adjusted by provincial inflation (VND: Billion), from the annual provincial Statistical Yearbook
FDINV	Foreign directly investment	Provincial foreign direct investment adjusted by provincial inflation (VND Billion), from the annual provincial Statistical Yearbook
LTRAN	Labour in economic	The share of total trained working labour in economic by total working labour (%), from the annual provincial Statistical Yearbook
COVID19	Experiencing COVID-19	Experiencing the crisis caused by the COVID-19 epidemic in 2019 that lasted into 2020 and has had aftershocks until now; COVID19 = 1 if year = 2019, 2020, 2021, 2022 COVID19 = 0 the remaining years

Source: Authors.

Economic growth—ΔlnY: is typically measured by the increase in the annual nominal gross regional domestic product of localities (GRDP) or the per capita gross domestic product adjusted by the province's average annual consumer price index of the province over a specific period (Adenuga and Evbuomwan, 2013; Barro, 1991; Bon, 2019; Dinh Thanh et al., 2020; Mankiw et al., 1992).

Public governance—GOV: Utilizing the Provincial Competitiveness Index (PCI) and PCI component indexes to represent local public governance (Thanh and Canh,

2019). Nine sub-indicators, including market entry costs, land access, transparency, time costs, informal costs, dynamism, business support policies, labour training, and legal institutions, are substituted to assess the role of local public governance. Previous studies, such as Bon (2019), Dinh Thanh et al. (2020), Su and Bui (2017), Su and Nguyen (2021) have utilized the PCI and its component indexes as indicators of the quality of local governance.

Public Investment—PUINV: Measured by two sources, including the total investment capital in the public sector and public expenditure allocated for development investment, education, training, and healthcare purposes (Bah and Kpognon, 2021).

Private Investment—PIINV: is measured by the logarithm of local domestic private investment. The variable "private" includes its current values and lags. The influence of private investment on growth cannot be ignored because much evidence has been provided about this strong correlation through many previous documents (Bah and Kpognon, 2021; Dinh Thanh et al., 2020; Su and Bui, 2017). Furthermore, Bukhari et al. (2007) argue that including private investment in observations in the model allows to take into account two phenomena: (1) the phenomenon that private investment can enhance growth if it complements public investment according to neoclassical theory; (2) private investment can reduce or compensate for the growth.

Foreign Direct Investment—FDINV: measured by the total foreign direct investment (FDI) in the locality. Similar to the role of domestic private investment, FDI inflows are separated from the total private capital of the economy, therefore its presence in the model is necessary (Agosin and Machado, 2005). The linkages between FDI inflows and economic growth have been recognized, and other related linkages between FDI, public investment, private investment and public governance have also been studied (Safae and Radouane, 2023; Su and Bui, 2017).

Labour—LTRAN: measured by the ratio of trained workers working in the total population of the economy. The influence of labour on growth demonstrating its role in the production function is an important control variable that cannot be ignored in the model (Barro, 1990, 1991).

Dummy variable experiencing the COVID-19 crisis—COVID19: the COVID-19 pandemic caused a very strong impact on the economy in 2019 and 2020 in all aspects and continued through the following years 2021 and 2022 affecting various sectors and industries in Vietnam (Ngo and Duong, 2023; Nguyen et al., 2022; Vo and Tran, 2021). In fact, only a few economic sectors have entered a state of recovery, the rest are still affected by this crisis, and therefore this is also a factor that needs to be controlled when observing changes in economic growth (König and Winkler, 2020; Martínez-Córdoba et al., 2021) during the study's concluding period.

4. Results and discussion

In this section, we present a summary of the final results obtained from the Spatial Durbin Model (SDM) outlined in Section 3. The empirical analysis utilizes province-level spatial panel data encompassing 63 provinces over the period from 2006 to 2022. The data on macroeconomic indicators, such as nominal GRDP per capita adjusted for inflation based on the provincial CPI price index, public investment capital, domestic

private investment capital, foreign direct investment capital, population, and labour, are sourced from the annual statistical yearbooks of the General Statistics Office of Vietnam (GSO). Data on the public governance index completely inherits and uses the provincial competitiveness index set developed and collected annually by VCCI Vietnam. The dataset includes information on the PCI score index and the scores of its ten components: Entry Costs, Access to Land, Transparency, Time Costs, Informal Charges, Proactivity, Business Support Policy, Labor Policy, Law & Order, and Policy Bias. However, since the Policy Bias index is not a continuous variable, it was removed from the analysis. Therefore, this article only utilized the remaining nine sub-indices, which are continuous data, for the econometric model.

The basic description of the data used in the article includes descriptive statistics such as minimum, maximum, mean, standard deviation, and correlation tests among the variables of the model components, presented in Appendix A. In Appendix B, unit root tests were conducted to ensure that the data used in the econometric model are reliable and not influenced by non-stationary data, which can cause variance changes. The Levin-Lin-Chu unit root test for panel data (Levin et al., 2002) was applied to our dataset, which consists of 1071 observations from 63 provinces/cities. This test is suitable for large, strongly balanced panel data like ours, with each province/city having between 10 to 25 observations. The results in Appendix B show that the time series are stationary, indicating that they are suitable for further analysis in the model.

Because the variables in the model exhibit spatial dependence, Moran's statistic for spatial correlation was calculated. **Figure 3** shows Moran's scatterplots for the variables used in the econometric model. Nearly all variables in the model display the spatial correlation between provinces/cities. Provinces that are closer together exhibit stronger spatial correlation, while those farther apart have weaker correlation.

Figure 4 examines the data of the variables in the model from a spatial viewpoint. It reveals that provinces that are close to each other often share similar colors in patches or clusters. Particularly for the three indicators of growth, public administration, and public investment, there's a clear pattern of spatial correlation between localities. Similar color clusters are evident and tend to extend further into the surrounding region. This observation aligns with the technical analysis of the data mentioned earlier, ensuring consistency in processing econometric models.

Furthermore, because of how the data is handled for the spatial Durbin dynamic model, which is suitable for panel data, we use the Hausman test to determine whether to use the fixed effects spatial model (RE-SDM) and the random effects spatial model (FE-SDM)(LeSage, 2015). The hypothesis of a random effect is rejected if the p_value > 0.05. The results in the tables below eliminate models that are statistically rejected according to the Hausman test.

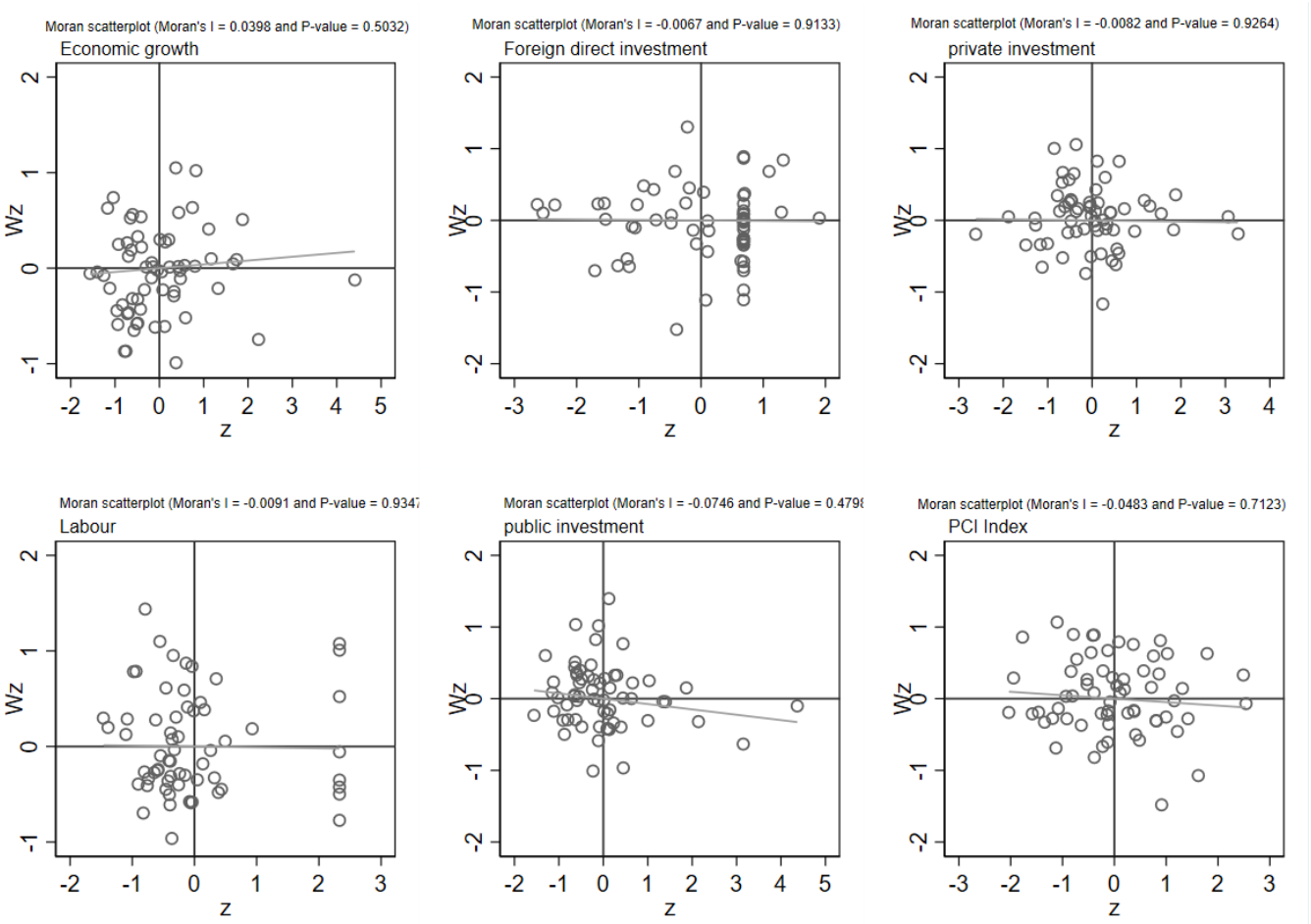

Figure 3. Moran's I statistic scatter plot.

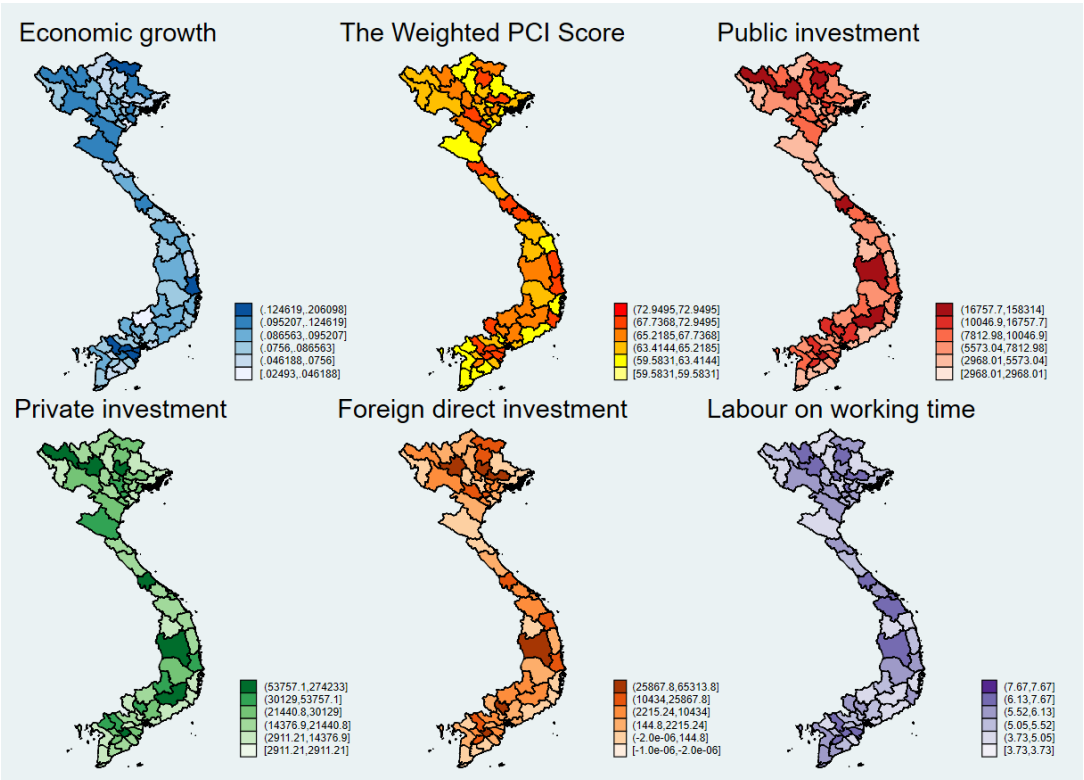

Figure 4. Indicators of 63 provinces of Vietnam in 2022.

First, different versions of the dynamic SDM model are dedicated to experiments with variations in the form of PCI including PCI (PCI) and lag of PCI (lagPCI) and different interactions with public investment variable (PUINV) including interaction variable PCI (PCI × PUINV) and the interaction variable of PCI lag (lagPCI × PUINV) were included in the estimates. The lagged growth variable interacting with the spatial matrix demonstrates the dynamic characteristics of this model (Elhorst, 2014). Including the lagged PCI variable in the model is based on descriptive statistical analysis and previous research indicating that improvements in the business environment assessed by the PCI index may have a delayed impact. Activities aimed at improving this year's PCI score can affect the economy in the following year. The main findings are presented in **Table 2**, while **Table 3** shows both long-term and short-term effects.

The spatial Durbin model:

$$\Delta lnY_{i,t} = \alpha_0 + \alpha_1 WGOV_{i,t} + \alpha_2 WlnPUINV_{i,t} + \alpha_3 \mathrm{W}(GOV_{i,t} \times lnPUINV_{i,t}) + \alpha_4 WX_{i,t} + \beta_1 GOV_{i,t} + \beta_2 lnPUINV_{i,t} + \beta_3 (GOV_{i,t} \times lnPUINV_{i,t}) + \beta_4 X_{i,t} + u_{i,t} + \tau_{i,t} + e_{i,t} \quad (7)$$

The dynamic spatial Durbin model:

$$\Delta lnY_{i,t} = \alpha_0 + \rho W \Delta lnY_{i,t-1} + \alpha_1 WGOV_{i,t} + \alpha_2 WlnPUINV_{i,t} + \alpha_3 \mathrm{W}(GOV_{i,t} \times lnPUINV_{i,t}) + \alpha_4 WX_{i,t} + \beta_1 GOV_{i,t} + \beta_2 lnPUINV_{i,t} + \beta_3 (GOV_{i,t} \times lnPUINV_{i,t}) + \beta_4 X_{i,t} + u_{i,t} + \tau_{i,t} + e_{i,t} \quad (8)$$

where: $\Delta lnY_{i,t}$ indicates the economic growth of province *i* at time *t*; *W* is the normalized element weight matrix for neighborliness; $GOV_{i,t}$ is the public governance indicator of the province *i*, at time *t*; $X_{i,t}$ is a list of the control variables; u_i is a spatial specific effect controlling for time-invariant variables; $\tau_{i,t}$ is a time-specific effect accounting for spatial-invariant variables.

Table 2. Regression with multimodal PCI.

	(1)	(2)	(3)	(4)	(5)
Variables			**X**		
L.WlnY	0.7451***	0.7089***	0.7409***	0.7227***	0.7232***
	(0.096)	(0.097)	(0.096)	(0.096)	(0.096)
lnPUINV	0.0879***	0.0647***	−0.4241***	−0.4296***	−0.5230***
	(0.019)	(0.021)	(0.121)	(0.121)	(0.130)
PCI	0.0025	0.0001	−0.0081**	−0.0104***	−0.0053
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)
PCI#lnPUINV			0.0083***	0.0085***	0.0048*
			(0.002)	(0.002)	(0.003)
lagPCI		0.0039*		0.0046**	−0.0022
		(0.002)		(0.002)	(0.004)
lagPCI#lnPUINV					0.0054*
					(0.003)
lnPIINV	0.3077***	0.2674***	0.2780***	0.2716***	0.2743***
	(0.020)	(0.023)	(0.022)	(0.023)	(0.022)

Table 3. (*Continued*).

	(1)	(2)	(3)	(4)	(5)
Variables			**X**		
lnFDINV	0.0228***	0.0157***	0.0179***	0.0177***	0.0173***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
lnLTRAN	0.1527***	0.2367***	0.2211***	0.2284***	0.2220***
	(0.049)	(0.049)	(0.048)	(0.048)	(0.048)
COVID19	0.4008***	0.3545***	0.3072***	0.2929***	0.2819***
	(0.051)	(0.049)	(0.050)	(0.050)	(0.050)
WlnPUINV	0.1122	0.0941	1.6555***	1.7283***	1.9101***
	(0.075)	(0.079)	(0.468)	(0.467)	(0.521)
WPCI	0.0033	0.0040	0.0375***	0.0387***	0.0313**
	(0.006)	(0.007)	(0.011)	(0.012)	(0.015)
WPCI#lnPUINV			−0.0275***	−0.0284***	−0.0232**
			(0.008)	(0.008)	(0.011)
WlagPCI		0.0069		0.0060	0.0168
		(0.006)		(0.006)	(0.015)
WlagPCI#lnPUINV					−0.0086
					(0.011)
WlnPIINV	−0.0711	−0.0718	−0.0972	−0.1055	−0.1102
	(0.079)	(0.087)	(0.086)	(0.086)	(0.086)
WlnFDINV	0.0006	0.0097	0.0077	0.0104	0.0102
	(0.024)	(0.025)	(0.025)	(0.025)	(0.025)
WlnLTRAN	−0.3354***	−0.2057	−0.1641	−0.1255	−0.1079
	(0.115)	(0.158)	(0.158)	(0.159)	(0.159)
WCOVID19	−0.7621***	−0.7317***	−0.5651***	−0.5857***	−0.5639***
	(0.093)	(0.091)	(0.095)	(0.096)	(0.097)
rho	0.2537***	0.2663***	0.2944***	0.2749***	0.2788***
	(0.090)	(0.091)	(0.089)	(0.090)	(0.090)
sigma2_e	0.0388***	0.0347***	0.0340***	0.0337***	0.0335***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Constant					
Observations	1008	945	945	945	945
R-squared	0.759	0.613	0.367	0.306	0.286
Number of idprovince	63	63	63	63	63
AIC	−441.449	−517.6321	−472.025	−540.0013	−540.5853
BIC	−367.7131	−435.1619	−388.4577	−447.8288	−438.7104

Variables descriptions: Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

where:

Y = Gross provincial nominal product per capita adjusted by provincial inflation (VND Million),

$\Delta \ln Y = \ln(\frac{Y_{i,t}}{Y_{i,t-1}})$,

L.W$\Delta \ln Y$ = The lagged value of the change in $\Delta \ln y$,

lnPUINV = The natural logarithm value of public investment (PUINV),

PCI = The Weighted Provincial Competitiveness Index Score,

PCI#lnPUINV = The interactive value of public governance (PCI) and public investment (lnPUINV),

lagPCI = The lagged value of the PCI,

lagPCI#lnPUINV = The interactive value of lagPCI and lnPUINV,

lnPIINV = The natural logarithm value of domestic private investment (PIINV),

lnFDINV = The natural logarithm value of foreign direct investment (FDINV),

lnLTRAN = The natural logarithm value of the rate of trained woking labour by total population,

COVID19 = The COVID-19 Pandemic in 2019, 2020 and the effect later in 2021, 2022, get value 1 if year = 2019, 2020, 2021, 2022; and value 0 if not these years,

WlnPUINV, WPCI, W(c.PCI#c.lnPUINV), WlagPCI, W(c.lagPCI#c.lnPUINV), WlnPIINV, WlnFDINV, WlnLTRAN, WCOVID19 = spacial variables reflecting magnitudes in neighboring provinces for lnPUINV, PCI, PCI × lnPUINV, lagPCI, lagPCI#lnPUINV, lnPIINV, lnFDINV, lnLTRAN, COVID19,

rho = The scalar spatial autoregressive coefficient (Spearman's rho rank-order correlation coefficient),

sigma2_e = Variance indicator,

R-squared = The traditional 'goodness of fit' measure (the rho being the more relevant indicator of correlation),

Number of idprovince = Number of provinces in the sample,

AIC = The Akaike Information Criterion for model selection,

BIC = The Bayesian Information Criterion for model selection.

Table 4. Long-term and short-term effects.

Short-term						
	Direct	**indirect**	**total**	**Direct**	**indirect**	**total**
lnPUINV	0.0894***	0.0805*	0.1699***	0.0926***	0.0920**	0.1846***
	(0.019)	(0.045)	(0.051)	(0.019)	(0.044)	(0.051)
PCI	0.0028	0.0026	0.0054	0.0002	0.0022	0.0024
	(0.002)	(0.004)	(0.004)	(0.002)	(0.004)	(0.004)
lagPCI				0.0050**	0.0042	0.0092***
				(0.002)	(0.004)	(0.004)
lnPIINV	0.3072***	0.0045	0.3118***	0.3026***	−0.0041	0.2984***
	(0.019)	(0.049)	(0.052)	(0.019)	(0.049)	(0.049)
lnFDINV	0.0231***	0.0037	0.0267	0.0227***	0.0031	0.0257
	(0.006)	(0.014)	(0.016)	(0.006)	(0.014)	(0.016)

Table 5. (*Continued*).

Short-term						
	Direct	**indirect**	**total**	**Direct**	**indirect**	**total**
lnLTRAN	0.1501***	−0.1808***	−0.0306	0.1585***	−0.1462**	0.0123
	(0.048)	(0.067)	(0.065)	(0.050)	(0.069)	(0.064)
COVID19	0.3877***	−0.4070***	−0.0193	0.3714***	−0.4201***	−0.0486*
	(0.052)	(0.052)	(0.025)	(0.049)	(0.051)	(0.027)
Long-term						
	Direct	indirect	total	Direct	indirect	total
lnPUINV	0.1079***	0.2512**	0.3592***	0.1111***	0.2581***	0.3692***
	(0.022)	(0.103)	(0.118)	(0.022)	(0.097)	(0.111)
PCI	0.0034*	0.0080	0.0113	0.0005	0.0045	0.0050
	(0.002)	(0.007)	(0.008)	(0.002)	(0.007)	(0.008)
lagPCI				0.0059***	0.0124*	0.0183**
				(0.002)	(0.007)	(0.008)
lnPIINV	0.3324***	0.3051***	0.6375***	0.3233***	0.2530**	0.5762***
	(0.023)	(0.118)	(0.132)	(0.021)	(0.107)	(0.117)
lnFDINV	0.0254***	0.0298	0.0552	0.0247***	0.0255	0.0502
	(0.007)	(0.032)	(0.036)	(0.007)	(0.029)	(0.034)
lnLTRAN	0.1366***	−0.2269*	−0.0903	0.1505***	−0.1467	0.0038
	(0.049)	(0.128)	(0.142)	(0.050)	(0.122)	(0.132)
COVID19	0.3611***	−0.4636***	−0.1025*	0.3425***	−0.4933***	−0.1507**
	(0.050)	(0.068)	(0.059)	(0.046)	(0.070)	(0.059)

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Next, we alternately substitute the sub-indices of PCI into the position of PCI in Equation (8) and conduct the Hausman test to test for fixed effects model (FEM) and random effects model (REM) effects in order to select the appropriate model. The sign "GOV*" in the result tables represent the nine sub-indices of PCI. The results are displayed in **Table 4**, with **Table 5** also showing the long-term and short-term effects (full results display in Appendix C). Presenting the estimated results with various model handling techniques reveals the different interactions of public governance variables on the impact of public investment on economic growth.

Table 4. SDM dynamic model results (PCI and PCI component indices, with interaction variables).

	(1)	(5)	(9)	(13)	(17)	(21)	(25)	(29)	(33)	(37)
Variables	**PCI**	**ENTRY**	**LANDAC**	**TRANSPAR**	**TIMEC**	**INFCHAR**	**PROACTIV**	**SUPTSER**	**LABOLI**	**LAWORD**
lnPUINV	−0.4691***	0.0347	−0.0315	−0.4861***	0.1169*	0.0573	−0.0669	0.0060	−0.1345**	−0.0504
	(0.113)	(0.099)	(0.086)	(0.088)	(0.068)	(0.077)	(0.050)	(0.047)	(0.054)	(0.049)
c.GOV*#c.lnPUINV	0.0097***	0.0066	0.0169	0.0964***	−0.0047	0.0053	0.0299***	0.0144*	0.0438***	0.0260***
	(0.002)	(0.012)	(0.013)	(0.014)	(0.010)	(0.012)	(0.009)	(0.008)	(0.010)	(0.009)
GOV*	−0.0076***	−0.0062	−0.0394*	−0.1218***	0.0094	−0.0320*	−0.0361***	−0.0142	−0.0313**	−0.0081
	(0.003)	(0.020)	(0.020)	(0.022)	(0.016)	(0.019)	(0.012)	(0.012)	(0.016)	(0.014)
WlnPUINV	1.6284***	−0.1272	−0.4968	0.3619	0.3718	0.6181**	0.6512***	0.2234	0.6281***	0.6736***
	(0.448)	(0.368)	(0.350)	(0.320)	(0.238)	(0.304)	(0.204)	(0.170)	(0.214)	(0.199)
W(c.GOV*#c.lnPUINV)	−0.0265***	0.0294	0.0929*	−0.0431	−0.0417	−0.0768*	−0.1037***	−0.0242	−0.0991***	−0.1089***
	(0.008)	(0.045)	(0.051)	(0.052)	(0.036)	(0.044)	(0.034)	(0.027)	(0.038)	(0.035)
WGOV*	0.0318***	−0.0324	−0.0808	0.0379	0.0473	0.1542**	0.1117**	−0.0021	0.1062*	0.1129**
	(0.010)	(0.063)	(0.078)	(0.077)	(0.054)	(0.068)	(0.047)	(0.033)	(0.057)	(0.051)
rho	0.2709***	0.2662***	0.2547***	0.2509***	0.2520***	0.2691***	0.2767***	0.2459***	0.2734***	0.2640***
	(0.089)	(0.090)	(0.090)	(0.089)	(0.090)	(0.089)	(0.089)	(0.090)	(0.089)	(0.089)
sigma2_e	0.0375***	0.0388***	0.0386***	0.0372***	0.0388***	0.0385***	0.0380***	0.0386***	0.0377***	0.0378***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	1008	1008	1008	1008	1008	1008	1008	1008	1008	1008
R-squared	0.554	0.761	0.731	0.762	0.745	0.654	0.706	0.765	0.746	0.707
Number of idprovinces	63	63	63	63	63	63	63	63	63	63
AIC	−472.025	−435.8632	−443.0953	−479.1328	−436.6763	−444.0322	−456.6623	−443.5661	−465.0542	−462.5816
BIC	−388.4577	−352.2959	−359.528	−395.5655	−353.109	−360.4649	−373.095	−359.9988	−381.4869	−379.0143

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 5. Short-term and long-term effects of PCI component indices.

Variables	Short-term			Long-term		
	Direct	**Indirect**	**Total**	**Direct**	**Indirect**	**Total**
PCI	0.003	0.003	0.005	0.0034*	0.008	0.011
	(0.002)	(0.004)	(0.004)	(0.002)	(0.007)	(0.008)
ENTRY	0.004	0.004	0.007	0.005	0.011	0.015
	(0.010)	(0.014)	(0.013)	(0.010)	(0.024)	(0.026)
LANDAC	−0.014	0.029	0.015	−0.011	0.046	0.035
	(0.010)	(0.018)	(0.018)	(0.011)	(0.036)	(0.040)
TRANSPAR	0.003	−0.012	−0.009	0.002	−0.021	−0.019
	(0.011)	(0.021)	(0.021)	(0.011)	(0.041)	(0.046)
TIMEC	0.005	−0.001	0.003	0.005	0.002	0.006
	(0.009)	(0.016)	(0.017)	(0.009)	(0.033)	(0.037)
INFCHAR	−0.0221**	0.0239*	0.002	−0.0206**	0.028	0.007
	(0.010)	(0.014)	(0.013)	(0.010)	(0.026)	(0.028)
PROACTIV	−0.005	−0.004	−0.009	−0.006	−0.012	−0.018
	(0.007)	(0.013)	(0.015)	(0.007)	(0.027)	(0.030)
SUPTSER	0.003	−0.0178*	−0.0153**	0.000	−0.0328**	−0.0325**
	(0.008)	(0.010)	(0.007)	(0.008)	(0.016)	(0.016)
LAPOLI	0.0232**	−0.008	0.016	0.0239**	0.006	0.030
	(0.010)	(0.016)	(0.015)	(0.010)	(0.030)	(0.033)
LAWORD	0.0260***	−0.015	0.012	0.0260***	−0.005	0.021
	(0.008)	(0.012)	(0.012)	(0.008)	(0.023)	(0.025)

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

In addition, WΔlnY reflects the spatial interaction of economic growth and neighbouring localities, which is statistically significant in all versions of the SDM dynamic model. Considering Spearman's rho coefficient, both the static and dynamic models are statistically significant in all versions. Model selection criteria results based on Akaike (AIC) and Bayesian (BIC) indices support more dynamic version models. The coefficient sigma2_e supports the conclusion that approximately 95% of the population lies within two standard deviations of the mean for each of the alternative models.

The analysis of the results obtained solely focuses on addressing the main question: "How does local public governance impact the effect of local public investment on local and regional growth?" To answer this overarching question, the subsequent discussion will address a series of smaller questions, including: (1) How does local public investment impact local and regional economic growth when considering spatial logic? (2) How does local public governance influence local and regional economic growth when accounting for economic spatial dependence? and (3) How does the interaction between public investment and public governance affect the impact of public investment on growth?

Tables 2 and **3** provide insights into how local public investment affects local and regional economic growth when considering spatial logic. In Columns (1) and (2), the variables are shown to be independent, with no interaction variable present. The

regression coefficient of the public investment variable (lnPUINV) is positive and statistically significant at the 1% level, indicating that public investment by localities in Vietnam positively impacts economic growth. This finding aligns with several previous studies conducted in Vietnam by researchers such as Bon (2019), Dinh Thanh et al., (2020), Su and Bui (2017), Van Luong et al., (2020). However, the regression coefficient of the variable WlnPUINV in these models is not statistically significant, suggesting that there is no evidence of the influence of local public investment on the growth of neighboring localities in this scenario.

In Columns (3), (4), and (5), the interaction variables of public administration and public investment (PCIlnPUINV, lagPCIlnPUINV) are introduced. The regression coefficient result of lnPUINV remains statistically significant at the 1% level, but the direction of the effect is reversed, showing a negative sign. The magnitude of the coefficient also increases nearly 7 times compared to the results in Columns (1) and (2). This suggests that local public investment now has a negative impact on the growth of that locality. After accounting for errors due to econometric technical processing, the cause is attributed to the appearance of interaction variables in the model. Additionally, the regression coefficient of the variable WlnPUINV becomes statistically significant with a positive sign at the 1% significance level. This indicates that local public investment now has a significantly positive effect on the economic growth of neighboring localities or regional growth. This finding is somewhat similar to some previous studies such as Johansson et al. (2001), Rodríguez-Pose et al. (2012), Safae and Radouane (2023), Van Luong et al. (2020).

Let's delve into the analysis of the impact of local public investment on short- and long-term economic growth. **Table 3** displays the results regarding the effects of independent variables on the dependent variable. Direct effects signify how local public investment affects local growth, while the indirect effect reflects its influence on the growth of neighboring localities, also known as the spillover effect. The total effect combines both direct and indirect effects. The results indicate that the variable lnPUINV has statistically significant effects at the 1% level and shows positive signs in all effects (direct, indirect, and total) for both short and long terms in both the baseline model and when the lagPCI variable occurs. Previous studies on Vietnam conducted by Canh and Phong (2018), Luat et al. (2016), Nguyen (2021) have assessed the influence of public investment on economic growth over various periods, including short-term and long-term. Nguyen (2021) discovered a negative impact of public investment on economic growth in the long term, while no such evidence was found in the short term. Similarly, Luat et al. (2016) identified limitations in the quality and efficiency of Vietnam's public investment, with no evidence supporting its effectiveness in the short run, despite a long-term relationship existing between public investment and economic growth. However, most of these studies overlooked the influence of economic spatial dependence due to territorial factors. In contrast, our results demonstrate evidence of the impact of public investment in both the short and long term. Additionally, we not only focused on the local area but also assessed the spillover effect of public investment on the economic growth of neighboring localities. These findings underscore the significant effects of spatial dependence and advocate for its inclusion in future economic studies.

Under normal circumstances, we haven't seen interactions between public administration and public investment, which aligns with findings from previous

studies in Vietnam (Bon, 2019; Dinh Thanh et al., 2020) and globally (ADB et al., 2016). Typically, local public investment positively impacts local economic growth but doesn't extend to neighboring areas or regional economic growth. However, when these interactions do occur, local public investments significantly boost regional economic growth while hindering local growth within the region. The appearance of interactive variables between public investment and public administration may be responsible for this shift.

The following analysis addresses the question of how local public governance affects local and regional growth, with results presented in **Tables 2—5**. The regression coefficients for the variables PCI and lagPCI indicate the impact of local public administration on local economic growth. Meanwhile, the coefficients for the variables WPCI and WlagPCI reflect the influence of local public administration on the economic growth of neighboring areas or regions. **Tables 2** and **3** utilize the PCI index as a measure of public governance quality in localities, whereas **Tables 4** and **5** examine the impact using the nine component indices of PCI.

The results in columns (1) and (2) of **Table 2** indicate that the regression coefficients for the variables PCI, WPCI, and WlagPCI are not statistically significant. Only the lagPCI variable shows statistical significance at a 10% level, suggesting a minimal impact of PCI on local economic growth, with this effect being delayed by one year. These findings suggest that the influence of local public governance on local economic growth is weak and slow in the absence of interaction between public investment and public governance. Moreover, local public administration does not appear to affect regional economic growth. This contrasts with previous studies examining the impact of public administration on economic growth in Vietnam at the provincial level, such as Bon (2019), Dinh Thanh et al. (2020), Nguyen and van Dijk (2012). Most of these studies have discovered a significant and positive impact of public administration on economic growth, as indicated by the PCI index representing public administration. However, their findings were primarily focused on the impact within the locality itself, without considering the effects on neighboring localities or regions. Additionally, the results of studies by Bon (2019) and Dinh Thanh et al. (2020) were observed in the context of interactions between PCI and other variables present in the model. These interaction variables included public investment (Bon, 2019), private investment (Dinh Thanh et al., 2020), or fiscal decentralization (Thanh and Canh, 2020).

When interactions between public governance and public investment occur, the results in columns (3), (4), and (5) of **Table 2** reveal some significant findings. The regression coefficients of the variables PCI and WPCI show statistical significance at the 1% level. However, the coefficient of PCI is negative, while that of WPCI is positive. Additionally, the lagPCI variable exhibits statistical significance at the 5% level with a positive coefficient, whereas the WlagPCI variable does not show statistical significance. These outcomes suggest that when interactions between public investment and public governance are observed, PCI negatively affects local economic growth but positively influences the growth of neighboring localities or regions. Furthermore, the lagPCI variable implies that efforts in local public governance positively impact local economic growth but with a lagged effect, while showing no significant lagged effect on regional growth. These findings align somewhat with previous studies conducted in Vietnam, such as Bon (2019), Dinh Thanh et al. (2020),

Thanh and Canh (2020), and Thanh and Hoai (2019), which also found significant effects of local public governance on local economic growth when considering interactions with other independent variables. However, a notable difference is that while those studies reported positive effects of public administration on growth, our results show the opposite. This outcome is somewhat akin to the findings of Nguyen and van Dijk (2012), who suggested that local public governance might impede local economic growth. However, their study did not examine the impact of local public governance on regional economic growth, which is a focus of our investigation.

Further investigation into the effects of local public governance on local and regional economic growth reveals insights over time, considering both short-term and long-term impacts. **Table 3** provides a glimpse into these findings. In the short term, the PCI shows no significant impact on economic growth at both local and regional levels. However, the lagPCI variable demonstrates notable effects, particularly in column (4) of **Table 3**, where it exhibits significance at a 5% level. This suggests that in the short term, the lagPCI directly influences local economic growth without any indirect effects. Looking at the long term, the PCI directly affects local economic growth without spillover effects. Conversely, the lagPCI variable presents more promising outcomes, showing statistical significance across all effects, including indirect, direct, and total effects. This implies that in the long term, the lagPCI variable significantly impacts local economic growth at a 1% level directly and has an indirect effect at a 10% level on neighboring localities' or regions' economic growth. Previous studies have generally overlooked the influence of public governance on economic growth over time, especially in short and long-term perspectives.

Furthermore, we delved deeper into understanding how public administration affects economic growth by examining the various components of the PCI index separately and incorporating them into our analysis. The results are outlined in **Tables 4** and **5**. In instances where interactions between public governance and public investment weren't apparent (**Table 5**), we discovered evidence indicating the influence of certain PCI component indicators on both local economic growth (direct effect) and regional growth (indirect effect) in the short term. Notably, indicators such as unofficial costs, labor policies, and legal institutions exhibited a significant direct impact on local economic growth at the 5% (INFCHAR, LAPOLI) and 10% (LAWORD) significance levels. The impact of the IFCHAR variable shows a negative effect, whereas the other two indices have a positive effect. This suggests that informal costs are a major obstacle to local economic growth, while indicators related to labor policies (LAPOLI) and legal institutions (LAWORD) contribute significantly to boosting local economic growth. These findings are somewhat consistent with previous studies by Dinh Thanh et al. (2020), Su and Bui (2017), and Thanh and Hoai (2019), particularly regarding the aspect of informal costs. However, when considering indirect effects, only 2 out of 9 indices are statistically significant at the 10% level in terms of their impact on the economic growth of neighboring localities. These include informal costs (INFCHAR) with a positive effect and business support services (SUPTSER) with a negative effect. This suggests that in the short term, an increase in informal costs in a locality can actually stimulate economic growth in neighboring areas. In the long term, improving local business support services can actually slow down economic growth in neighboring areas. The long-term effects mirror those found in the short term, with only the business support index (SUPTSER)

showing statistical significance for indirect effects. No statistical evidence was found for the informal cost index or other indexes. Therefore, both in the short and long term, an increase in local informal costs impedes local economic growth but aids regional economic growth. On the other hand, enhancing labor policies, legal frameworks, and business support services can boost local economic growth without affecting regional economic growth. However, better business support service policies may not necessarily stimulate local economic growth and could even hinder economic growth in neighboring areas. These results also do not indicate how other components of the PCI index influence local and regional economic growth.

When interactions between public governance and public investment are considered in the model (**Table 5**), we see more interesting results compared to **Table 4**. Many of the sub-indices of the PCI show statistical significance. The regression coefficients associated with the variable denoted GOV* for indicators like land access (LANDAC), transparency (TRANSPAR), informal costs (INFCHAR), proactivity (PROACTIV), and labor policy (LABOLI) are statistically significant at the 1%, 5%, and 10% levels, all with negative signs. This suggests that aspects such as land access, transparency, informal costs, proactivity, and labor policy, which represent the quality of public governance in localities, are hindering local economic growth. Additionally, the regression coefficients associated with the variable denoted WGOV* for indicators like informal costs (INFCHAR), proactivity (PROACTIV), labor policy (LABOLI), and legal institutions (LAWORD) are statistically significant at the 1% and 10% levels, all with positive signs.

This result suggests that certain aspects of public administration, like informal costs, proactivity, labor policy, and local legal institutions, have a positive impact on boosting economic growth in nearby areas. Hence, some aspects of public administration in Vietnam hinder local economic growth but help in promoting economic growth in neighboring areas or regions. The aspects of land access and transparency seem to impede local economic growth without affecting neighboring areas. Informal costs, proactivity, and labor policies show signs of hindering local growth but have the opposite effect on promoting economic growth in neighboring areas or regions. The legal institution doesn't seem to directly affect local economic growth, but it does have a positive impact on promoting regional economic growth. These findings are somewhat similar to those of previous studies by Dinh Thanh et al. (2020), Su and Bui (2017), Thanh and Canh (2020), Thanh and Hoai (2019) regarding the negative effects on local economic growth of certain PCI component indices. However, these previous studies did not assess their indirect effects on neighboring areas. The main difference here is that when interactions between public administration and public investment haven't appeared, there's also no evidence of significance in the statistics of the business support index. These differences could be because of the interaction variable between public investment and public administration.

In conclusion, we address the question "How does public governance influence the impact of public investment on economic growth in both local areas and neighboring regions?" The results from **Tables 2** and **4** reveal key insights. We examine the estimated coefficients linked to the interaction variables labeled PCI#lnPUINV, lagPCI#lnPUINV, WPCI#lnPUINV, WlagPCI#lnPUINV, GOV*# lnPUINV, and W(GOV*#lnPUINV). **Table 2** findings indicate that the estimated

coefficients of both interaction variables PCI#lnPUINV (with a positive sign) and WPCI#lnPUINV (with a negative sign) are statistically significant at the 1%, 5%, and 10% levels. This suggests that the interplay between public administration and public investment has a positive impact on promoting local economic growth but hampers the economic growth of neighboring areas. The coefficient of the interaction variable lagPCI#lnPUINV is statistically insignificant at the 10% level, indicating that this interaction variable associated with the spatial matrix does not hold statistical significance.

Table 4 reveals that the estimated coefficients of the interaction variables labeled GOV*#lnPUINV are statistically significant at the 1% and 10% levels. These coefficients all have positive signs in the models corresponding to the PCI component indexes, including transparency, dynamism, business support, labor policy, and legal institutions. This suggests that the interaction of these PCI aspects with public investment has a positive influence, boosting local economic growth. However, the estimated coefficients of these interactions associated with the spatial matrix of indicators like land access, informal costs, dynamism, labor policies, and legal institutions are also statistically significant. At the 1% and 10% levels, these coefficients all have negative signs, except for the land access index, which has a positive sign. This indicates that the interaction between these PCI component indexes and public investment might hinder economic growth in neighboring areas. On the other hand, the interaction between the land access component index and public investment promotes economic growth in neighboring localities and the region.

Here's a recap of the main findings presented in this article:

1) When public governance and public investment don't interact, local public investment boosts local economic growth without extending to nearby areas or affecting regional growth in the short and long run. However, when these interactions occur, local public investments spur regional economic growth significantly while slowing down local growth. This shift may be due to the interactive variables between public investment and public administration.
2) When public governance and public investment don't interact, the influence of local public governance on local economic growth is minimal and gradual, only becoming apparent over the long term. Additionally, local public administration doesn't affect regional economic growth in this scenario. However, when these interactions occur, local public governance negatively affects local economic growth but significantly boosts the economic growth of nearby areas or regions.
3) The different aspects of public administration are represented by various component indices of PCI. When interactions between public governance and public investment are absent, we notice that an increase in local informal costs hampers local economic growth in both the short and long term but helps promote regional economic growth. Meanwhile, improved labor policies, laws, and institutions boost local economic growth without affecting regional economic growth. However, when these interactions occur, aspects like informal costs, dynamism, labor policies, and local legal institutions positively influence economic growth in neighboring areas. On the other hand, land access and transparency hinder local economic growth without impacting neighboring areas. Although informal costs, dynamism, and labor policies hinder local growth, they

promote economic growth in neighboring regions. Legal institutions do not affect local economic growth but promote regional economic growth.

4) The interaction between public governance and public investment has a positive impact on promoting local economic growth but hinders the economic growth of neighboring areas or regions. The interaction of PCI component aspects with public investment, including transparency, dynamism, business support, labor policies, and legal institutions, positively contributes to promoting local economic growth. However, the interaction between PCI component indices (informal costs, dynamism, labor policies, and legal institutions) and public investment shows signs of hindering economic growth in neighboring areas and regions. On the other hand, the interaction between the land access component index and public investment promotes economic growth in neighboring areas and regions.

The change of effects caused by public investment, and public governance of economic growth occurs when interactions between public investment and public governance appear in the model. Therefore, these interaction terms can be considered as a core factor for both positive and negative effects on local and regional economic growth. Why is that so, local public investment projects operate in the ecological environment created and enhanced by public governance strategies, so the public investment efficiency is closely affected by decisions to change local government strategy. The selection of places to implement public investment projects such as infrastructure construction, and providing essential public services related to education, labor and health leads to many results. Growth can be promoted due to the efficiency of infrastructure operations that reduce logical costs, leading to attracting the private sector. The businesses always choose one that has a higher level of infrastructure development locality or their neighbours instead of other localities. For example, enterprise A chose to build a business in Long An instead of Ben Tre because Long An is located next to Ho Chi Minh City. The high level of infrastructure development of Ho Chi Minh City leads to a decrease in logistics costs which supports A when A wants to improve revenue by commercial goods through export or supply to the Ho Chi Minh City market itself. Infrastructure traps may also appear in Ho Chi Minh City. When the infrastructure level is too high, leading to increased real estate prices and higher fixed costs for build up or business facilities activities. So, enterprises will choose nearby locations to reduce investment fixed costs. Thus, a public governance strategy of Ho Chi Minh City has the potential to affect its growth and the neighboring locality as Long An through interacting with public investment activities.

Deeply, when observing the effect of interactions between PCI component indicators—different aspects representing public administration show different aspect indicators have different effects on the dynamic impact of public investment in local and regional economic growth. For example, while the interaction of component indicators includes Proactivity, Labor policies and Law & Order have a positive influence, contributing to promoting local economic growth but there are signs of hindering the economic growth of neighboring localities or areas. Or the interaction terms of the Transparency sub-index, Businesses support policy sub-index has a positive significant influence on local economic growth but has no effect on the region. These results imply that each component aspect of public governance represents different quality assessments from different aspects of the economy. The implication

is that local public governance plays the role of enhancing and improving the business system, thereby promoting potential activities to deform growth through public investment efficiency. It can be seen that Proactivity, Labor policies and Law & Order are important aspects and interaction with public investment, showing the efficiency of public investment is dependent on these aspects. An improvement that increases the quality of these aspects will enhance public investment efficiency and thereby promote economic growth.

5. Conclusions and policy

The article systematically investigates and analyzes the moderating influence of public governance on the relationship between public investment and economic growth in the Vietnamese context. The main objective is to contribute to the existing literature on the effects of local public government, local public investment and their interaction terms in local and regional economic growth. The experimental model built with the local growth function is based on the assumption that the local government can intervene to amplify or hinder the effects of public investment in local and regional growth through public governance policies. By based on decision policies to increase the quality of public governance, thereby improving the efficiency of public investment, changing the spatial structure of the economic activities and the impact on economic growth deformation in both local and neighbour areas. This experimental study is based on the database of 63 provinces in Vietnam from 2006 to 2022.

With the experimental version of the spatial Durbin model, interesting findings include two main groups. First, when the interactions between public governance and public investment have not yet appeared in the model: (i) the local public investment has a positive impact on local economic growth but does not spread to neighboring localities or does not affect regional economic growth in the both short and long term; (ii) The influence of local public governance on local economic growth is faint and slow, only in the long term and has no spread of any effect on regional economic growth; (iii) In both short -term and long -term, the increase of locality informal charges has prevented the local economic growth, but contributed to promoting regional economic growth. Better labour policies and laws & order will boost local economic growth but have no impact on regional economic growth.

Secondly, when interactions between public governance and public investment appear in the model: (i) both public investment and local public governance have significant positive effects that promote neighborhood economic growth but are hindering local growth; (ii) several different component indicators of the PCI index represent local public governance aspects that have different effects on local and regional economic growth. The land-to-access and transparency sub-indexes show signs of hindering the development of the local economy and do not have any effect on neighborhood provinces. The informal charges, proactivity and labor policies show signs of preventing local growth but have the positive effect of promoting the economic growth of neighboring provinces or regions. The legal institution shows no signs of its influence on local economic growth but has a positive significant influence in promoting regional economic growth; (iii) interactive variables between public governance and public investment have a positive significant influence on promoting local economic growth but preventing the economic growth of neighboring localities or regions; However, there are differences in the effects of these interactions on local

and regional economic growth when replacing the PCI index with its component indices. The interaction of indicators includes proactivity, labor policies and law & order, which have a positive influence, contributing to promoting local economic growth, but there are signs of hindering the economic growth of neighboring localities or areas. The interaction of the transparency and business support indexes has a positive effect on local economic growth but does not affect the region. In contrast, the interaction between the land-to-access and public investment components stimulates regional economic growth without any local growth. The interaction of the informal charge index shows signs of preventing regional economic growth and does not affect the locality.

The results imply that the interaction between public governance and public investment plays an important role in adjusting the effects of public investment and public governance on economic growth not only in the locality but also radiating to neighboring localities. The local authorities should exploit deeper interaction between public investment and public governance when designing strategic policies for local development in the context of the spatial economic dependence is exists. Public investment policies need public governance strategies to achieve maximum efficiency investment not only in the internal area but also in inter-regional. It's in turn that the public governance policies are close to the reality of localities characteristics include population, resident, immigration, labors, demographic, geography, and economy in each territory, thereby achieving appropriate governance strategies to promote the private zone efficiency leading to promoting economic growth. Moreover, spillover effects emerge as a pivotal factor in regional policy cooperation to mitigate economic disparities arising from geographical factors. The implication is that policy-makers and authorities should prioritize regional collaboration when shaping public governance strategies and allocating public funds.

In addition, the results of detailed analysis of PCI component indicators show that many aspects of local public governance are hindering local economic growth but contributing to promoting neighboring localities economic growth. Or, it has no effect the locality but promote or hinder the regional economic growth. The findings in this study implies that authorities of localities need to be cautious when using resources to improve the various aspects of public governance when designing strategies to enhance the quality of local public governance. They should continue to maintain public governance strategies in governance aspects contributions to local growth, align with that they should review and change governance strategies for harmful governance aspects to growth. Cooperative strategies between localities can also take place to contribute to public governance strategies that both parties are mutually beneficial.

The presented results in this article are grounded in rigorous statistical techniques, data robustness, and careful interpretation of econometric models. It is therefore more interesting to observe similar findings in different panel databases set. In general, this article shed light on the nature and importance role of local public governance in affecting the impact of public investment on economic growth not only in the locality but also neighboring localities. Although both public investment and public governance have a very important independent influence on economic growth as we know in this experiment and the literatures, the quality of public governance only creates a better ecosystem, making an important contribution to strengthening positive interactions of public investment on economic growth. Within the finite framework of

this study, it is a pity that there is no examining for the level industry. That is interesting for this model in the level industry. Or can focus on exploiting deeper interactions between public governance and each type of public investment for different infrastructure items such as energy, electricity, water or soft infrastructure - the digital government for deformations in local and regional economic growth.

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Appendix A

Table A1. Statistical table describing variable indicators.

	(1)	(2)	(3)	(4)	(5)
Variables	**N**	**Mean**	**std. dev.**	**Min**	**Max**
PCI	1071	59.67	6.125	36.40	77.20
COVID19	1071	0.235	0.424	0	1
lnY	1071	1.094	0.819	−1.085	3.631
lnPUINV	1071	1.336	0.681	−0.734	3.105
lnPIINV	1071	1.849	0.839	−1.890	3.725
lnFDINV	1071	−0.826	2.328	−10.74	4.240
lnLTRAN	1071	2.777	0.408	1.504	3.918
ENTRY	1071	7.795	0.853	4.960	9.600
LANDAC	1071	6.410	0.822	3.040	8.840
TRANSPAR	1071	5.977	0.763	2.150	8.850
TIMEC	1071	6.453	1.134	2.640	9.500
INFCHAR	1071	6.210	0.983	2.810	8.940
PROACTIV	1071	5.454	1.283	1.390	9.390
SUPTSER	1071	5.623	1.258	1.750	9.620
LAPOLI	1071	5.591	1.062	1.700	9.600
LAWORD	1071	5.590	1.325	2	8.600
Number of idprovince	63	63	63	63	63

Table A2. Table of correlations between variables.

	lnY	**PCI**	**lnPUINV**	**lnPIINV**	**lnFDINV**	**lnLTRAN**	**COVID19**
lnY	1.0000	-	-	-	-	-	-
PCI	0.6326	1.0000	-	-	-	-	-
lnPUINV	0.5780	0.3103	1.0000	-	-	-	-
lnPIINV	0.8183	0.5866	0.5786	1.0000	-	-	-
lnFDINV	0.5448	0.3998	0.2357	0.4437	1.0000	-	-
lnLTRAN	0.4888	0.3336	0.5220	0.5083	0.4652	1.0000	-
COVID19	0.5111	0.4882	0.3624	0.5491	0.1704	0.3430	1.0000

Table A3. Partial and semipatial correlations of lnY with independence variables in model.

Variables	**Partial corr.**	**Semipartial corr.**	**Partial corr.^2**	**Semipartial corr.^2**	**Significance value**
PCI	0.2703	0.1385	0.0731	0.0192	0.0000
lnPUINV	0.2711	0.1390	0.0735	0.0193	0.0000
lnPIINV	0.5385	0.3154	0.2900	0.0995	0.0000
lnFDINV	0.3383	0.1774	0.1145	0.0315	0.0000
lnLTRAN	−0.0644	−0.0319	0.0042	0.0010	0.0354
COVID19	0.0963	0.0478	0.0093	0.0023	0.0016

Appendix B

Table B1. Table of stationarity tests.

Variables	Levin–Lin–Chu unit-root test		
	Unadjusted	**Adjusted t***	***p*-value**
lnY	−15.3189	−5.4134	0.0000
lnPUINV	−15.6817	−3.2859	0.0005
lnPIINV	−22.4302	−11.1867	0.0000
lnFDINV	−14.7292	−2.0266	0.0214
lnLTRAN	−16.0212	−1.6195	0.0527
D.lnLTRAN	−33.9626	−19.2405	0.0000
PCI	−17.8576	−4.3505	0.0000
ENTRY	−22.9719	−8.2013	0.0000
LANDAC	−17.7152	−4.2566	0.0000
TRANSPAR	−22.2752	−8.8871	0.0000
TIMEC	−21.8669	−7.1663	0.0000
INFCHAR	−20.6718	−4.2281	0.0000
PROACTIV	−19.4766	−6.2500	0.0000
SUPTSER	−22.5185	−5.7488	0.0000
LAPOLI	−21.1480	−5.7799	0.0000
LAWORD	−20.7182	−3.7616	0.0001

Appendix C

Table C1. Dynamic SDM model (PCI and PCI component indices, NON interaction variables).

	(1)	(5)	(9)	(13)	(17)	(21)	(25)	(29)	(33)	(37)
VARIABLES	**PCI**	**ENTRY**	**LANDAC**	**TRANSPAR**	**TIMEC**	**INFCHAR**	**PROACTIV**	**SUPTSER**	**LABOLI**	**LAWORD**
L.WlnY	0.7451***	0.7151***	0.7308***	0.7294***	0.7256***	0.7333***	0.7153***	0.7272***	0.7141***	0.7325***
	(0.096)	(0.097)	(0.095)	(0.095)	(0.095)	(0.096)	(0.096)	(0.095)	(0.096)	(0.094)
lnPUINV	0.0879***	0.0875***	0.0842***	0.0873***	0.0867***	0.0862***	0.0860***	0.0841***	0.0889***	0.0823***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.020)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
GOV*	0.0025	0.0026	−0.0161	0.0027	0.0035	−0.0239**	−0.0052	0.0021	0.0223**	0.0255***
	(0.002)	(0.011)	(0.011)	(0.011)	(0.009)	(0.010)	(0.007)	(0.008)	(0.011)	(0.008)
lnPIINV	0.3077***	0.3155***	0.3162***	0.3137***	0.3144***	0.3151***	0.3176***	0.3153***	0.3068***	0.3123***
	(0.020)	(0.019)	(0.019)	(0.020)	(0.019)	(0.019)	(0.020)	(0.019)	(0.020)	(0.019)
lnFDINV	0.0228***	0.0224***	0.0219***	0.0224***	0.0226***	0.0207***	0.0224***	0.0231***	0.0218***	0.0219***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
lnLTRAN	0.1527***	0.1552***	0.1524***	0.1531***	0.1531***	0.1457***	0.1540***	0.1525***	0.1415***	0.1517***
	(0.049)	(0.050)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)
COVID19	0.4008***	0.4105***	0.4202***	0.4105***	0.4063***	0.4351***	0.4145***	0.4063***	0.4075***	0.3633***
	(0.051)	(0.051)	(0.050)	(0.050)	(0.051)	(0.051)	(0.051)	(0.050)	(0.050)	(0.052)
WlnPUINV	0.1122	0.1112	0.1368*	0.0993	0.1098	0.1141	0.1043	0.0949	0.1181	0.1107
	(0.075)	(0.075)	(0.077)	(0.077)	(0.078)	(0.075)	(0.076)	(0.075)	(0.076)	(0.075)
WGOV*	0.0033	0.0049	0.0504	−0.0221	−0.0051	0.0442*	−0.0070	−0.0296*	−0.0187	−0.0309
	(0.006)	(0.024)	(0.031)	(0.036)	(0.028)	(0.024)	(0.023)	(0.018)	(0.028)	(0.021)
WlnPIINV	−0.0711	−0.0346	−0.0550	−0.0320	−0.0405	−0.0510	−0.0310	−0.0197	−0.0372	−0.0443
	(0.079)	(0.073)	(0.072)	(0.073)	(0.072)	(0.072)	(0.075)	(0.072)	(0.073)	(0.072)
WlnFDINV	0.0006	−0.0022	−0.0027	−0.0026	−0.0026	0.0003	−0.0015	0.0054	−0.0018	−0.0042
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)

Table C1. (*Continued*).

	(1)	(5)	(9)	(13)	(17)	(21)	(25)	(29)	(33)	(37)
VARIABLES	**PCI**	**ENTRY**	**LANDAC**	**TRANSPAR**	**TIMEC**	**INFCHAR**	**PROACTIV**	**SUPTSER**	**LABOLI**	**LAWORD**
WlnLTRAN	−0.3354***	−0.3261***	−0.3283***	−0.3288***	−0.3296***	−0.3146***	−0.3225***	−0.3088***	−0.3264***	−0.3363***
	(0.115)	(0.116)	(0.115)	(0.115)	(0.116)	(0.115)	(0.115)	(0.115)	(0.117)	(0.115)
WCOVID19	−0.7621***	−0.7509***	−0.7901***	−0.7579***	−0.7497***	−0.8038***	−0.7425***	−0.7396***	−0.7462***	−0.6847***
	(0.093)	(0.092)	(0.093)	(0.090)	(0.092)	(0.096)	(0.096)	(0.090)	(0.090)	(0.094)
rho	0.2537***	0.2627***	0.2595***	0.2598***	0.2615***	0.2641***	0.2600***	0.2428***	0.2634***	0.2585***
	(0.090)	(0.090)	(0.090)	(0.090)	(0.090)	(0.090)	(0.090)	(0.090)	(0.090)	(0.090)
sigma2_e	0.0388***	0.0389***	0.0388***	0.0389***	0.0389***	0.0387***	0.0389***	0.0387***	0.0387***	0.0385***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	1008	1008	1008	1008	1008	1008	1008	1008	1008	1008
R-squared	0.759	0.761	0.743	0.763	0.763	0.742	0.761	0.765	0.766	0.766
Number of idprovinces	63	63	63	63	63	63	63	63	63	63
AIC	−441.449	−439.1472	−442.3516	−439.1426	−438.9478	−444.6007	−439.6727	−443.731	−443.4785	−448.001
BIC	−367.7131	−365.4114	−368.6157	−365.4067	−365.212	−370.8649	−365.9368	−369.9951	−369.7427	−374.2652

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table C2. Dynamic SDM model (PCI and PCI component indices, with interaction variables)

	(1)	(5)	(9)	(13)	(17)	(21)	(25)	(29)	(33)	(37)
VARIABLES	**PCI**	**ENTRY**	**LANDAC**	**TRANSPAR**	**TIMEC**	**INFCHAR**	**PROACTIV**	**SUPTSER**	**LABOLI**	**LAWORD**
L.WlnY	0.7618***	0.7116***	0.7406***	0.7177***	0.7316***	0.7173***	0.7033***	0.7291***	0.7190***	0.7212***
	(0.095)	(0.097)	(0.095)	(0.095)	(0.095)	(0.096)	(0.095)	(0.095)	(0.096)	(0.094)
lnPUINV	−0.4691***	0.0347	−0.0315	−0.4861***	0.1169*	0.0573	−0.0669	0.0060	−0.1345**	−0.0504
	(0.113)	(0.099)	(0.086)	(0.088)	(0.068)	(0.077)	(0.050)	(0.047)	(0.054)	(0.049)
c.GOV*#c.lnPUINV	0.0097***	0.0066	0.0169	0.0964***	−0.0047	0.0053	0.0299***	0.0144*	0.0438***	0.0260***
	(0.002)	(0.012)	(0.013)	(0.014)	(0.010)	(0.012)	(0.009)	(0.008)	(0.010)	(0.009)
GOV*	−0.0076***	−0.0062	−0.0394*	−0.1218***	0.0094	−0.0320*	−0.0361***	−0.0142	−0.0313**	−0.0081
	(0.003)	(0.020)	(0.020)	(0.022)	(0.016)	(0.019)	(0.012)	(0.012)	(0.016)	(0.014)

Table C2. (*Continued*).

	(1)	(5)	(9)	(13)	(17)	(21)	(25)	(29)	(33)	(37)
VARIABLES	**PCI**	**ENTRY**	**LANDAC**	**TRANSPAR**	**TIMEC**	**INFCHAR**	**PROACTIV**	**SUPTSER**	**LABOLI**	**LAWORD**
lnPIINV	0.3150***	0.3151***	0.3176***	0.3201***	0.3146***	0.3157***	0.3173***	0.3174***	0.3093***	0.3175***
	(0.020)	(0.020)	(0.019)	(0.019)	(0.020)	(0.019)	(0.019)	(0.019)	(0.020)	(0.019)
lnFDINV	0.0248***	0.0225***	0.0214***	0.0217***	0.0232***	0.0199***	0.0214***	0.0237***	0.0237***	0.0238***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
lnLTRAN	0.1375***	0.1542***	0.1470***	0.1562***	0.1531***	0.1457***	0.1518***	0.1561***	0.1372***	0.1466***
	(0.048)	(0.050)	(0.049)	(0.048)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)
COVID19	0.3219***	0.4124***	0.4188***	0.3911***	0.4023***	0.4275***	0.3611***	0.3919***	0.3748***	0.3172***
	(0.052)	(0.051)	(0.050)	(0.049)	(0.051)	(0.051)	(0.052)	(0.051)	(0.050)	(0.053)
WlnPUINV	1.6284***	−0.1272	−0.4968	0.3619	0.3718	0.6181**	0.6512***	0.2234	0.6281***	0.6736***
	(0.448)	(0.368)	(0.350)	(0.320)	(0.238)	(0.304)	(0.204)	(0.170)	(0.214)	(0.199)
W(c.GOV*#c.lnPUINV)	−0.0265***	0.0294	0.0929*	−0.0431	−0.0417	−0.0768*	−0.1037***	−0.0242	−0.0991***	−0.1089***
	(0.008)	(0.045)	(0.051)	(0.052)	(0.036)	(0.044)	(0.034)	(0.027)	(0.038)	(0.035)
WGOV*	0.0318***	−0.0324	−0.0808	0.0379	0.0473	0.1542**	0.1117**	−0.0021	0.1062*	0.1129**
	(0.010)	(0.063)	(0.078)	(0.077)	(0.054)	(0.068)	(0.047)	(0.033)	(0.057)	(0.051)
WlnPIINV	−0.1071	−0.0306	−0.0346	−0.0206	−0.0509	−0.0516	−0.0433	−0.0262	−0.0482	−0.0675
	(0.078)	(0.073)	(0.073)	(0.074)	(0.073)	(0.072)	(0.074)	(0.072)	(0.072)	(0.071)
WlnFDINV	−0.0012	−0.0014	−0.0042	−0.0205	0.0018	0.0021	0.0029	0.0032	−0.0071	−0.0109
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
WlnLTRAN	−0.2818**	−0.3149***	−0.3688***	−0.3535***	−0.3103***	−0.3008***	−0.2772**	−0.3151***	−0.3388***	−0.2540**
	(0.115)	(0.117)	(0.116)	(0.113)	(0.117)	(0.115)	(0.117)	(0.118)	(0.116)	(0.120)
WCOVID19	−0.5928***	−0.7426***	−0.8038***	−0.7166***	−0.7150***	−0.7768***	−0.6166***	−0.7146***	−0.6825***	−0.5620***
	(0.098)	(0.093)	(0.094)	(0.089)	(0.096)	(0.097)	(0.101)	(0.091)	(0.090)	(0.099)
rho	0.2709***	0.2662***	0.2547***	0.2509***	0.2520***	0.2691***	0.2767***	0.2459***	0.2734***	0.2640***
	(0.089)	(0.090)	(0.090)	(0.089)	(0.090)	(0.089)	(0.089)	(0.090)	(0.089)	(0.089)

Table C2. (*Continued*).

	(1)	(5)	(9)	(13)	(17)	(21)	(25)	(29)	(33)	(37)
VARIABLES	**PCI**	**ENTRY**	**LANDAC**	**TRANSPAR**	**TIMEC**	**INFCHAR**	**PROACTIV**	**SUPTSER**	**LABOLI**	**LAWORD**
sigma2_e	0.0375***	0.0388***	0.0386***	0.0372***	0.0388***	0.0385***	0.0380***	0.0386***	0.0377***	0.0378***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	1008	1008	1008	1008	1008	1008	1008	1008	1008	1008
R-squared	0.554	0.761	0.731	0.762	0.745	0.654	0.706	0.765	0.746	0.707
Number of idprovinces	63	63	63	63	63	63	63	63	63	63
AIC	−472.025	−435.8632	−443.0953	−479.1328	−436.6763	−444.0322	−456.6623	−443.5661	−465.0542	−462.5816
BIC	−388.4577	−352.2959	−359.528	−395.5655	−353.109	−360.4649	−373.095	−359.9988	−381.4869	−379.0143

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.