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Investigating the Infrastructure Competitiveness Performance of Cities in Northern Mindanao, Philippines: A Panel Data Analysis

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ABSTRACT

Assessing the infrastructure competitiveness performance of cities is one way of evaluating the status of a certain city. The study aims to assess the changes of the competitive index of cities in Region 10 from 2019-2023 and to predict the infrastructure performance of Region 10 using the other three pillars of competitiveness index. Due to time indexed factor of the data, this paper employed two-way repeated measure ANOVA and panel regression specifically the correlated panel-corrected standard error (PCSE) to investigate the change of infrastructure performance over 5-time period and predict the infrastructure performance of the Northern Mindanao based on the other pillars of competi- tiveness, respectively. The study revealed that a significant change in infrastructure performance of cities in northern Mindanao is observed over the 5-year time period. Moreover, it was found out that the infrastructure performance of northern Mindanao significantly varies among its 9 cities. Further investigation showed that the infrastructure competitiveness performance of the cities in northern Mindanao is significant- ly predicted by its competitiveness performance in terms of economic dynamism, government efficiency and resiliency.

Keywords: Competitiveness, Infrastructure, One-way repeated measure ANOVA, Correlated PCSE

1 INTRODUCTION

Competitiveness is defined as a strong desire to achieve greater success than others. The quality of being good or better than those in a similar field. Youth opportunities, firm efficiency, cluster prosperity and sustainability, city and region sustainability, and international business are all shaped by competitiveness (Huggins and Thompson 2017).

Cities face an endeavor of being competitive in the economic aspect and that is through competitive government. Competitive government as a new philosophy that provides the framework for the public sector reform and continual renewal (Mendoza 2020). In addi- tion, a competitive government takes a wider view of competition, free of the terms, assumptions, and perceptions associated with good governance and business friendliness indices (Im and Hartley 2017).

As one of the pillars of competitiveness, infrastructure plays an important role in attaining and sustaining economic growth and development (Serafica 2000). Basic inputs of production such as energy, water; interconnection of production which includes transportation, roads, and communications; sustenance of production such as waste, disaster preparedness, environmental sustainability and human capital formation infrastructure are included in the infrastructure index.

In the Philippine setting, Northern Mindanao or Region 10 is one of the fastest growing regions of the country (Bokingo 2010). Located in the northern part of Mindanao, it serves as the island group- ing's gateway to and from other regions of the country. It is com- posed of five provinces: Bukidnon, Camiguin, Misamis Occidental, Misamis Oriental, and Lanao Del Norte. These five provinces, which comprises nine cities: Cagayan de Oro, El Salvador, Gingoog, Iligan, Malaybalay, Oroquieta, Ozamiz, Tangub, and Valencia. It includes 84 municipalities, and 2,022 barangays which make up Northern Mindanao. Despite their differences in resource endowments, the various LGUs sought to optimize their individual capacity while also complementing one another. Through the years amidst the growing tourism and livelihood of Region 10, the measure of competitiveness is still important to see if the region is productive in certain indica- tors. Motivated by the build build build program or the “golden age of infrastructure” of former Pres. Rodrigo R. Duterte, this study seeks to assess the infrastructure performance of region 10 from 2019-2023.

This study aims to assess the significant changes in the infrastructure competitiveness index of cities in Region 10 from 2019 to 2023 and to predict the infrastructure performance of Region 10 using the other three pillars of the competitiveness index. The research prob- lem focuses on determining whether there are differences in each city's infrastructure competitiveness index in Region 10 over a five- year period.

As one of the leaders in formulating policies and inspiring com- panies, the Department of Trade and Industry (DTI) and Local Gov- ernment Units (LGUs) in Region 10 will be able to benefit from the reliable information this study can offer. Additionally, it gives indus- trial and local businesses the knowledge they need to offer sugges- tions on how to keep the city competitive and make more advance- ments in terms of infrastructure.

2 METHODOLOGY

2.1 Conceptual Framework

The conceptual framework consists of the four pillars of the Competitiveness index of cities vital for the assessment of competitiveness. Competitiveness index of cities Region 10 was assessed according to their recorded score to every sector related to each pillar. The researchers assessed each score of every city including the Economic dynamism, Infrastructure, Government, and Resiliency scores as shown in each factor of competitiveness in National Competitiveness theory of Porter (1990).

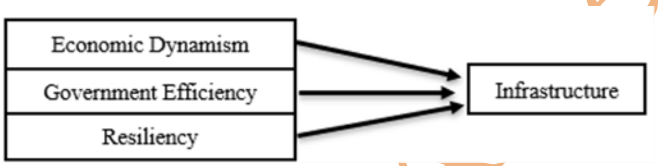

Figure 1. Conceptual Framework: Assessment of the Competitive- ness of Cities in Region 10.

2.2 Empirical framework

This paper adopted the concepts of (Catipay et al., 2018) in assessing the competitiveness of cities and municipalities. The varia- bles involved the four pillars of competitiveness which are economic dynamism, government efficiency, infrastructure and resiliency. The study seeks the influence of three pillars on the infrastructure performance of cities in region 10 as shown in Figure 1.

According to the Department of Trade and Industry, the key indi- cator of Infrastructure represents the sustainability of productivity over time. It refers to the physical building blocks that connect, ex- pand, and sustain a locality and its surroundings to enable the provi- sion of goods and services (Department of Trade and Industry, 2021). Cities and Municipalities Competitive Index define the competi- tiveness of the cities and municipalities and also encompasses the four pillars.

Empirical Model

The Department of Trade and Industry adopts four pillars to measure the competitiveness of the cities and municipalities in the Philip- pines. These are economic dynamism, government efficiency, infra- structure and resilience. As shown in equation 2.1 is the empirical model that was used in this study. The equation shows that infra- structure (I) depends on the economic dynamism (ED), government efficiency (GE), and resiliency (R).

$$I_{it} = \beta_0 + \beta_1 ED + \beta_2 R + \beta_3 GE + \varepsilon \quad (2.1)$$

Where:

$$I_{it} = Infrastructure$$
$$\beta_0 = Constant$$
$$\beta_n = coefficient\ of\ independent\ variable$$
$$ED = Economic\ Dynamism$$
$$GE = Government\ Efficiency$$
$$R = Resiliency$$

2. 3.1 Hypothesis

The following null hypothesis will be tested at 95% level of significance and a 5% margin of error.

H_{01}: There is no significant change in infrastructure performance of cities in Region 10 over a 5-year period (2019-2023).

H_{02}: Indicators such as Economic dynamism, infrastructure, and resiliency have no significant influence on the infrastructure perfor- mance of cities in Region 10 over the year 2019 – 2023.

2.3 Data

All data used in this study can be obtained and accessed using the link Data Portal - Cities and Municipalities Competitive Index (dti.gov.ph). The Infrastructure performance of the cities is assessed based on the sum of the scores of its 10 indicators such as 1. Existing road network 2. Distance from City/Municipality Center to Major Ports 3. DOT-Accredited Accommodations 4. Availability of Basic Utilities 5. Annual Investments in Infrastructure 6. Connection of ICT 7. Number of Public Transportation Vehicles 8. Health Infra- structure 9. Education Infrastructure 10. Number of ATMs. All exist- ing scores of the data are continuous. They are computed using a composite index method. For instance, to reflect the various aspects of infrastructure performance, it involves the use of relevant sub- indicators such percentage of paved roads, availability of utilities (electricity, water, telecommunications), distance to ports or airports, number of public transportation vehicles, number of health and edu- cation facilities, number of government facilities, etc. According to the Department of Trade and Industry, the higher the score, the more competitive it is.

2.3.1 Statistical Tool

Since the data involves observation on multiple entities (cities) over multiple time period (2019-2023), this paper utilized two-way repeated measure ANOVA and Panel regression using Correlated Panel-Corrected Standard Error (PCSE). The two-way repeated measure ANOVA was used to examine the difference in infrastructure performance among 9 cities of Northern Mindanao over a 5- year time period. On the other hand, Correlated Panel-Corrected Standard Error (PCSE) was used to investigate the influence of eco- nomic dynamism, government efficiency, and resiliency on the infra- structure performance of cities in Northern Mindanao from the year 2019 to 2023.

3 RESULTS AND DISCUSSIONS

This chapter presents the analysis, interpretation and discussion of the results. The results are presented based on the order of the objectives of the study.

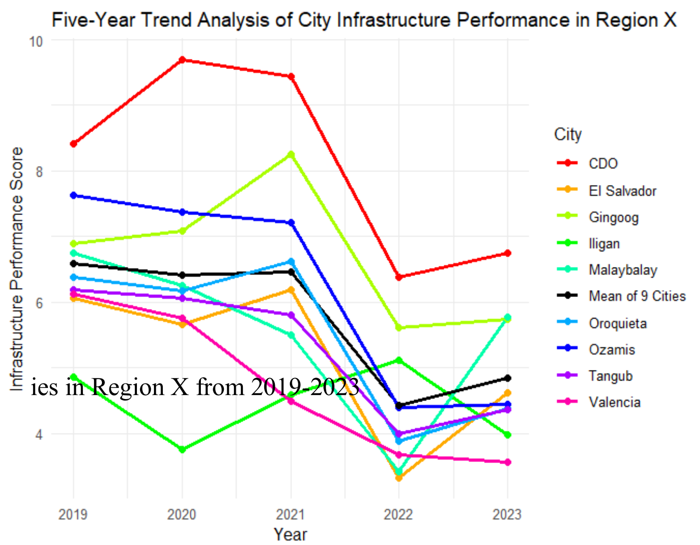

Figure 1 the Infrastructure Performance of 9 Cities in Region 10

Figure 1 presents the five-year trend analysis of city infrastructure performance in Region 10 (2019–2023). As observed, there is a clear downward trend in the recorded performance values across the major cities in Region 10. Most cities experienced a peak around 2020 or 2021, followed by a significant decline in 2022 and 2023. For instance, Cagayan de Oro (CDO) city, which consistently had the highest values from 2019 to 2021, showed a marked drop from 9.44 in 2021 to 6.39 in 2022 and remained relatively low at 6.75 in 2023. A similar pattern is also evident in other cities like Gingoog, Ozamis, and Malaybalay, where values declined after reaching their peak in earlier years. In the same time period, Iligan city shows the lowest infra- structure performance among the 9 cities with a mean score of 4.46 which is much lower compared to 5.75 overall score.

Moreover, based on the overall regional mean score as shown in black color, it reflects a downward trend. It decreased from 6.59 in 2019 to 4.85 in 2023, with the lowest point recorded in 2022 at 4.43. This suggests that the decline was not isolated but rather systemic across the region. Notably, cities like Iligan and Valencia consistently recorded values below the regional mean. This indicates possible long-standing challenges or slower recovery rates. Meanwhile, El Salvador and Tangub also followed the general decline, but with smaller fluctuations. This reflects a relatively moderate performance throughout the five-year period. This downward trend may point to underlying regional disruptions including economic shocks, policy shifts, or the lingering impact of the COVID-19 pandemic during the years 2020 to 2022. The gradual recovery or stabilization in 2023, though still below pre-pandemic levels shows an ongoing adjustment efforts of the region to recovery.

Table 1 Infrastructure Performance Comparison among cities in Region 10 over a 5-year period.

Between-subjects error term: Cities					
Levels: 9					
Repeated Variable: Year					
Source	SS	*df*	MS	F	P-value
Cities	51.10	8	6.39	12.57	<0.0001*
Year	37.97	4	9.49	18.67	<0.0001*
Residual	16.27	32	0.51		
Total	105.34	44	2.39		
Huynh-feldt epsilon = 0.9814 (p-value = <0.0001)					

Sphericity assumption is not violated, (*) Significant at 0.05 (p<0.05)

Table 1 presents the result of comparison analysis on the infra- structure performance among nine cities in region 10. The analysis employed the two-way repeated measures analysis of variance (ANOVA) to examine the significant difference of infrastructure performance among 9 cities of northern Mindanao over a 5-year time period. Mauchly's test shows that sphericity assumption is not violated. This is also asserted by the result of Huynh-feldt epsilon where the result is the same with regular p-value (<0.0001). This means that the variances of the differences between all combinations of repeated measures (e.g., years) are approximately equal.

Based on the repeated measures ANOVA results, it reveals that both the city and the year had a statistically significant effect on the infrastructure performance of Region 10 from 2019 to 2023. Specifically, the between-subjects factor, 'cities' yielded a p-value of <0.0001 which is significantly less than the level of significance at 5%. This indicates a highly significant difference in performance among the nine cities. This suggests that infrastructure development and performance varied notably across the different urban areas. Potentially, this is due to disparities in resource allocation, local governance, or development priorities. Similarly, the within-subjects factor 'year' also shows a computed p-value of <0.0001 which also points to a significant variation in performance over the five-year period. This trend implies that infrastructure performance was not stable across time and has been influenced by external factors such as the COVID-19 pandemic, shifts in national policy, or regional economic conditions.

Specifically, a significant decrease in infrastructure performance in Northern Mindanao is observed during the year 2022 which is also the end of the presidency of former Pres. Rodrigo R. Duterte. Moreover, the relatively low residual mean square value (0.51) further suggests that the model effectively explains a substantial portion of the variability in the data.

Table 2 Shapiro-wilk Test for Normality

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
economicdy~m	45	0.98544	0.630	-0.978	0.83591
government~y	45	0.97186	1.219	0.419	0.33758
infrastruc~e	45	0.95946	1.756	1.193	0.11646
resiliency	45	0.88511	4.975	3.400	0.00034

Null: The data is normally distributed

Table 2 presents the result of the Shapiro-Wilk test to examine whether the variables such as economic dynamism, government efficiency, infra- structure performance and resiliency follow a normal distribution. Normality is one of the most fundamental assumptions that affect the statistical power of many parametric tests including the ANOVA and regression model. Famous for its reliable power to assess normality, the Shapiro-wilk test shows that all variables except resiliency fol- lows a normal distribution. However, in a regression setting, the de- pendent variable must satisfy the normality assumption because it will be reflected in the residual error and the residual must follow a normal distribution. In this case, the dependent variable is the infra- structure performance and it is normally distributed.

Table 3 Wooldridge Test for Autocorrelation

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Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,         8) =       0.427
              Prob > F =      0.5320
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The Wooldridge test for autocorrelation in panel data is a statistical test used to detect the presence of first-order serial correlation or autocorrelation in the idiosyncratic errors of a panel data regression model. If autocorrelation exists, it violates a key assumption of classical regression which is independent errors. This violation leads to biased standard errors and misleading p-values. This requires adjustment by using robust standard errors or generalized least squares (GLS) methods. Based on the result, the computed p-value of 0.5320 ($p>0.05$) shows that there is no autocorrelation observed in the panel data.

Table 4 Pesaran Test for Corelation

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Pesaran's test of cross sectional independence =     2.856, Pr = 0.0043
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Null: There is no cross-sectional dependence (residuals are independent across units)

The Pesaran's test of cross-sectional dependence is used to detect whether there is cross-sectional dependence (correlation) across the entities (e.g. cities) in the panel data. It seeks to test whether the residuals (errors) of the panel regression model for different cross-sectional units are correlated with each other at the same point in time. As observed, a computed p-value of 0.0043 is much lesser than 0.05 level of significance. This means that null hypothesis is reject- ed. Therefore, the Pesaran test reveals that there is a cross-sectional dependency across the cities ($p<0.05$). This means that the error terms (residuals) across different cross-sectional units (e.g. cities) are correlated at the same time period.

Table 5 Variance Inflation Factor (VIF) for Multicollinearity

Variable	VIF	1/VIF
government~y	2.37	0.421262
economicdy~m	2.01	0.498398
resiliency	1.76	0.569601
Mean VIF	2.05	

The Variance Inflation Factor (VIF) is a diagnostic measure used to detect multicollinearity in a regression model. It assesses whether two or more independent (predictor) variables are highly correlated with each other. It quantifies how much the variance of a regression coefficient is inflated due to multicollinearity. A VIF > 5 or 10 signals that the model has unstable coefficient estimates due to high correlation among predictors, and corrective action is needed. Based on the computed variance inflation factors which are all lower than 0.5, multicollinearity is not a concern in the model.

Table 6 Breusch-Pagan Test for Heteroskedasticity

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of infrastructure

         chi2(1)      =     0.24
         Prob > chi2  =   0.6209
```

The Breusch-Pagan test is a statistical test used to detect heteroskedasticity in a regression model. It tests whether the variance of the residuals (errors) is constant (homoskedasticity) or changes with the values of the independent variables. Based on the result, there is a constant variance in the residual ($p>0.05$). Thus, the assumption of constant variance is satisfied in the regression model.

Table 7 The Correlated PCSE Table for predicting Infrastructure performance of cities in Region 10

Linear regression, Correlated panels corrected standard error (N = 45)				
Group variable: ID Time variable: Year		Panels: Correlated No autocorrelation R-squared = 0.6226		
		Panel Corrected		
Infrastructure (I)	Coef.	S.E.	Z	P-value
Economic Dynamism (ED)	0.2685	0.11	2.35	0.019*
Government Efficiency (GE)	0.2576	0.11	2.25	0.024*
Resiliency (R)	0.2333	0.08	3.01	0.003*
Constant	-1.2687	0.99	-1.28	0.200

(*) Significant at 0.05

Table 7 presents the result of correlated panel-corrected standard error model to examine the significant influence economic dynamism, government efficiency and resiliency on the infrastructure performance of cities in northern Mindanao over a 5-year time period. This model considers the possibility of contemporaneous correla- tions, accounting for the deviations from spherical errors and allow- ing for better inference from linear models. Before proceeding, as- sumptions were first checked. The data is normal. The VIF value indicates no issue of multicollinearity. Pesaran test shows that the panel data is correlated and no auto correlation as confirmed by woodridge test. Lastly, the variance error is constant. The PCSE regression model has the best fit since it satisfies the assumptions and conditions of the panel data as compared to random-effects and fixed effects panel models.

Based on the result of the correlated PCSE model, it shows that the economic dynamism, government efficiency, and resiliency have a positive influence on infrastructure performance among the cities in Northern Mindanao at a 5% significance level. This suggests that the improvements in these competitiveness pillars are associated with better infrastructure performance in the region. The empirical PCSE regression model is given by,

$$I=1.2687 + 0.2685\ (ED)+0.2576\ (GE)+0.2333(R)$$

The model reveals that an increase in one-point score of economic dynamism will lead to an increased score for infrastructure by 0.2685, assuming that all other indicators are held constant. This implies that cities with stronger local economies, characterized by higher business activity, employment, and investment, are more like- ly to have enhanced infrastructure performance in the region. In fact, the influence of economic dynamism on infrastructure is the strong- est among the three pillars.

Similarly, a one-point increase in government efficiency will result in 0.2576 increase in infrastructure performance where other indicators are assumed constant. This indicates that efficient, transparent, and responsive governance leads to improved infrastructure outcomes. For resiliency (coefficient = 0.2333, $p = 0.003$), it emphasizes the importance of disaster preparedness, environmental sustainability, and social protection systems in maintaining and developing infrastructure.

Whereas, the constant term is not statistically significant ($p = 0.200$) which indicates that when the predictors are zero, the baseline level of infrastructure performance does not significantly differ from zero. Moreover, the R-squared value of 0.6226 indicates that about 62.26 percent of the total variation or changes in the infrastructure performance of cities in the region 10 can be explained by the total variations or changes of economic dynamism, government efficiency, and resiliency. The rest of 37.74% can be attributed to other indi- cators not being considered in the fitted model.

Overall, it is clear that government efficiency, economic dyna- mism and resiliency have a direct positive influence on the infra- structure performance of cities in region 10. The findings show the importance of a multidimensional approach to improving infrastructure, where economic vitality, effective governance, and resilience- building strategies are integrated into local development planning.

4 CONCLUSION

In this paper, the author only focused on the Infrastructure perfor- mance of Region 10 in which it is relevant to the “build, build, build” program or the “Golden age of infrastructure” of former Pres- ident Rodrigo R. Duterte. This study only examined the infrastructure performance of nine cities in Region 10 (Northern Mindanao) from 2019 to 2023 and investigated the influence of key competitiveness pillars such as economic dynamism, government efficiency, and resiliency using a panel-corrected standard error (PCSE) regres- sion model. The findings reveal a consistent downward trend in infrastructure performance across the region during the study period, with the most pronounced decline occurring in 2022. This is possibly influenced by broader socio-economic disruptions such as the COVID-19 pandemic and political transitions. The two-way repeated measures ANOVA showed statistically significant differences in infrastructure performance across cities and over time. This confirmed that infrastructure development in the region is both spatially and temporally uneven. Moreover, the regression analysis demonstrated that all three predictors such as economic dynamism, government efficiency, and resiliency significantly and positively influence infra- structure performance of the region. Among them, economic dynamism emerged as the strongest predictor based on coefficient magni- tude which highlights the central role of a robust local economy in supporting infrastructure development. Government efficiency and resiliency also proved to be critical factors which reinforces the val- ue of good governance and disaster preparedness in sustaining infra- structure growth.

5 RECOMMENDATION

Based on the findings of this study, several key recommendations are proposed to enhance infrastructure performance in the cities of Region10. First, local government units (LGUs) should prioritize economic development as a driver of infrastructure growth. The study found that economic dynamism has the strongest positive influence on infrastructure performance. Programs that support local enterprises, encourage private investment, and expand employment opportunities can directly enhance the financial and operational capacity of cities to develop and maintain infrastructure systems. Second, it is crucial to strengthen government efficiency and accountability. Efficient governance characterized by streamlined processes, transparent budgeting, and effective pub- lic service delivery was also identified as a significant factor influencing infrastructure outcomes. LGUs must institutionalize performance-based governance practices and leverage digital tools to improve the planning, execution, and monitoring of infrastructure projects. Third, there is a pressing need to integrate resilience-building strategies into infrastructure planning. The study shows the importance of resiliency particularly in disaster preparedness, environmental protection, and social safety systems in ensuring long-term infrastructure sustainability. Local governments should embed climate adaptation and risk reduction components into infrastructure investments, while also collaborating regionally to address shared vulnerabilities and dependencies among cities.

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