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Spatial Inequality of Industrial Human Resources: A Composite LDGS Approach

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Abstract. This study analyzes the spatial dynamics of industrial human resources in North Kalimantan Province. Using secondary data (2011–2022), it applies a Composite LDGS Index integrating Location Quotient, Dynamic LQ, Growth Rate Model, and Shift Share, complemented by Klassen Typology and Moran's I–LISA spatial analysis. The findings reveal polarized industrial labor distribution, with Tarakan and Bulungan forming a high–high growth cluster, while Malinau and Tana Tidung remain low–low lagging regions. The results confirm that regional competitiveness and specialization dynamics, rather than growth alone, drive spatial inequality in industrial human resource development. Furthermore, infrastructure disparities, uneven investment flows, and differences in human capital quality contribute to the persistence of regional gaps. The study suggests that targeted regional policies, improved inter-district connectivity, and capacity-building programs are essential to reduce spatial inequality. Strengthening industrial linkages and promoting equitable development strategies are also crucial to enhance balanced growth across North Kalimantan Province and support long-term sustainable regional development outcomes.

Keywords: Industrial Human Resources; LDGS Index; North Kalimantan; Regional Competitiveness; Spatial Inequality.

1. BACKGROUND

Human resources (HR) are a fundamental factor in driving sustainable regional economic growth, particularly in the industrial sector, which acts as a driver of economic structural transformation. The quality, quantity, and balanced spatial distribution of HR are important prerequisites for increasing industrial productivity, regional competitiveness, and equitable development between regions. In the context of developing regions and new autonomous regions, the challenges of managing industrial HR tend to be more complex due to infrastructure limitations, disparities between regions, and dependence on natural resource-based sectors.

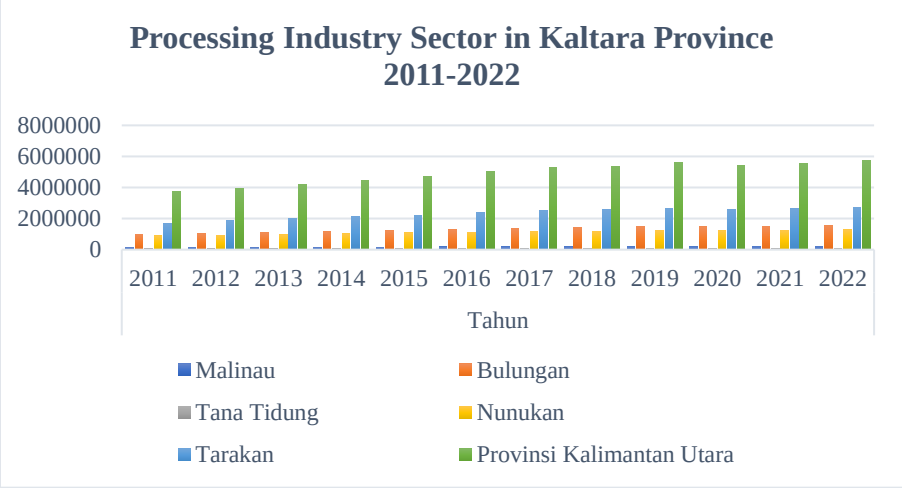

Figure 1. Value of the Manufacturing Sector in North Kalimantan Province 2011-2022.

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North Kalimantan Province, as the youngest province in Indonesia, has unique economic characteristics, marked by vast natural resource potential and relatively rapid growth in the manufacturing sector over the past decade. Data shows that the real output value of the manufacturing sector in North Kalimantan Province increased significantly during the 2011–2022 period, reflecting the expansion of manufacturing and processing activities based on local resources (Setiawan et al., 2024). This growth indicates a shift in the economic structure towards value-added sectors that are theoretically capable of creating quality jobs and improving community welfare.

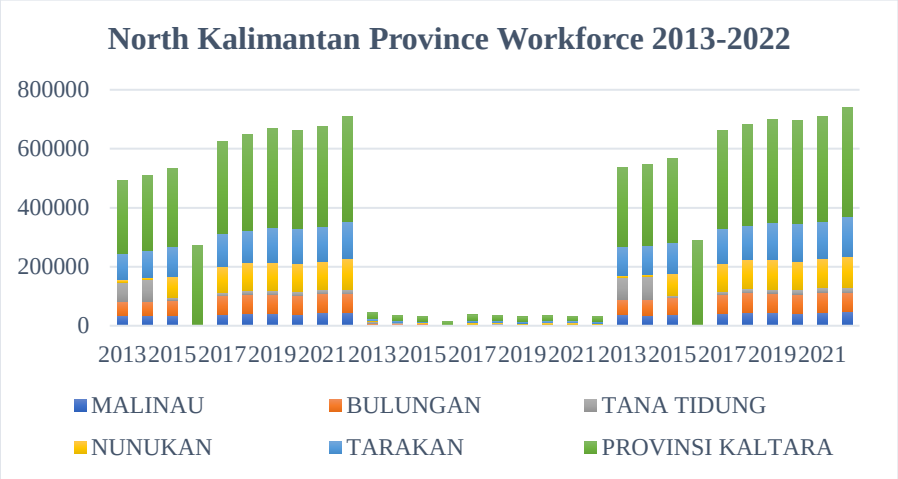

Figure 2. North Kalimantan Province Labor Force 2013-2022.

However, this economic output growth has not been fully accompanied by equitable distribution and improved quality of human resources across districts/cities. Employment data shows diverse spatial dynamics in terms of labor force numbers, unemployment rates, and labor force growth rates in each region. Certain regencies/cities, such as Tarakan and Nunukan, play a dominant role in industrial output, but this is not always in line with the proportion of the labor force or the competitive advantage of industrial human resources in a balanced manner. Conversely, several other regions show an increase in the workforce without being supported by comparable industrial output growth. This condition indicates spatial inequality in the absorption and utilization of human resources in the industrial sector in North Kalimantan Province (Provinsi Kalimantan Utara, 2025).

Spatial disparities in human resources in the industrial sector have the potential to cause various negative implications, including low labor market efficiency, regional productivity imbalances, and limited multiplier effects from industrial growth on inclusive regional development. Therefore, a comprehensive understanding of the spatial dynamics of industrial human resources is crucial as a basis for formulating regional-based industrial and employment development policies.

Previous studies have used the Location Quotient (LQ) approach to identify regional base sectors and comparative advantages (Hendayana et al., 2003), as well as Shift Share Analysis to analyze sources of sectoral growth and regional competitive advantages (Arsyad, 1999; Tarigan, 2005). Other studies have also utilized Dynamic Location Quotient (DLQ) and Growth Rate Model (GRM) to capture the dynamics of economic structure changes and sectoral growth rates over time (Putra & Kartika, 2013; Wibawa & Zulfikar, 2017). However, most of these studies are still partial, stand-alone, and have not integrated all indicators into a single composite measure capable of simultaneously representing the spatial dynamics of human resources and sectoral economic performance.

In addition, empirical studies on the spatial dynamics of human resources in the industrial sector in border areas and new provinces such as North Kalimantan are still relatively limited, especially those that combine sectoral, temporal, and spatial approaches in an integrated manner. These limitations open up space for the development of a more comprehensive methodological approach to explain the relationship between labor concentration, real economic output growth, and regional competitive advantage.

Based on these research gaps, this study aims to analyze the spatial dynamics of human resources in the industrial sector in North Kalimantan Province using the LDGS Composite Index (Location Quotient, Dynamic Location Quotient, Growth Rate, Shift Share). This index is designed to integrate various sectoral and employment performance indicators into a single composite measure that is capable of capturing the dimensions of concentration, growth dynamics, and regional competitive advantage in a more holistic manner. In addition, this study also utilizes Klassen's typology and spatial analysis to identify patterns of inequality as well as potential and underdeveloped regional clusters.

The main novelty of this study lies in the development and application of the LDGS Composite Index (Location Quotient, Dynamic Location Quotient, Growth Rate, Shift Share) as a composite analysis tool to examine the spatial dynamics of human resources in the industrial sector in an integrated manner. Unlike previous studies, which generally used LQ, DLQ, GRM, or Shift Share partially and separately, this study integrates all these indicators into a single z-score-based index that is capable of capturing the dimensions of sectoral concentration, temporal dynamics, real economic growth rates, and regional competitive advantages simultaneously. In addition, this study expands the conventional approach by combining the LDGS Index, Klassen Typology, and spatial analysis between districts/cities, thereby enabling a more comprehensive identification of patterns of inequality and clusters of industrial human resource dynamics. The application of this approach in the context of new

provinces and border regions such as North Kalimantan Province is a significant empirical contribution, Given the limitations of previous studies that directly link the distribution of industrial labor with real economic output growth within an integrated spatial framework.

Scientifically, this research has theoretical significance in enriching the literature on regional economics and employment through the development of a composite index approach based on the spatial dynamics of industrial human resources. From a practical and policy perspective, the results of this research are expected to form the basis for the formulation of more targeted, region-based industrial and human resource development policies oriented towards equitable development in North Kalimantan Province. The uniqueness and novelty of this research lies in the use of the LDGS Composite Index as an integrated analytical tool to examine the relationship between labor distribution and real sectoral economic output growth within a spatial framework, which to date has rarely been applied in the context of new provinces and border regions in Indonesia.

2. RESEARCH METHODOLOGY

Research Design and Data

This study uses an explanatory quantitative approach with a focus on analyzing the spatial dynamics of human resources (HR) in the industrial sector. The unit of analysis in this study is regencies/cities in North Kalimantan Province, with an annual observation period from 2011 to 2022.

The data used is secondary data, including:

a. Real output data for the manufacturing sector,
b. Data on the number of workers in the industrial sector,
c. Data on the labor force and unemployment,
d. Data on the total gross regional domestic product (GRDP) of the region.

All data was obtained from official publications of the North Kalimantan Provincial Statistics Agency (BPS) and the relevant regencies/cities. The data was tabulated and processed to ensure consistency between regions and periods before further analysis was carried out.

Analytical Framework

The analytical framework of this study was designed to answer the research objectives in examining the concentration, growth dynamics, and spatial inequality of human resources in the industrial sector. The analysis was carried out in four main stages:

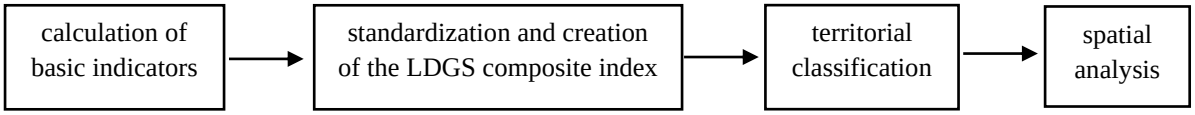

Figure 3. Analysis Framework.

Location Quotient (LQ)

Location Quotient (LQ) is used to measure the relative concentration level of industrial sectors in a region compared to a reference region. LQ is calculated using the following formula:

$$LQ_{i,j} = \frac{(E_{i,j}/E_i)}{(E_j/E)}$$

where:

$E_{i,j}$= output of industrial sector j in region i,

E_i = total output of all sectors in region i,

E_j = total output of industrial sector j in the reference region,

E = total output of all sectors in the reference region.

An LQ value greater than 1 indicates that the industrial sector has a higher level of specialization compared to the reference region, while an LQ value less than 1 indicates that the sector is relatively underdeveloped. In this study, LQ is used to identify the basis of industrial human resource concentration between regions (Hendayana et al., 2003).

Dynamic Location Quotient (DLQ)

The Dynamic Location Quotient (DLQ) is used to capture changes in sectoral concentration dynamics over time. DLQ is calculated as the difference in LQ values between periods:

$$DLQ_{t,t+1} = LQ_{t+1} - LQ_t$$

A positive DLQ value indicates an increase in industrial sector specialization, while a negative value indicates a decline in relative concentration. The DLQ serves to analyze the temporal dynamics of industrial human resources, complementing the static nature of the LQ.

Growth Rate Model (GRM)

The Growth Rate Model (GRM) is used to analyze the growth rate of industrial sector output at the district/city level compared to the reference region. GRM is formulated as the ratio of local sectoral growth to reference sectoral growth:

$$GR_{i,j} = \frac{g_{i,j}}{g_j}$$

where g_(i,j) is the growth rate of industrial sector output in region i, and g_j is the growth rate of the same sector in the reference region.

A GRM value >1 indicates that the industrial sector is growing faster than the reference region, while a GRM <1 indicates slower growth (Putra & Kartika, 2013; Wibawa & Zulfikar, 2017).

Shift Share Analysis (SS)

Shift Share Analysis is used to break down the sources of changes in industrial sector performance into three main components (Arsyad, 1999; Tarigan, 2005):

$$SS_i = NS_i + IS_i + CS_i$$

where:

National Share (NS): the influence of the reference region's economic growth,

Industry Mix (IS): the influence of the industrial sectoral structure,

Competitive Share (CS): regional competitive advantage.

This analysis is used to identify whether the growth of the industrial sector in a region is more influenced by national factors, industrial structure, or local advantages closely related to the quality of human resources.

Construction of the Composite LDGS Indeks

To overcome the limitations of partial analysis, this study constructed a Composite LDGS Index by integrating LQ, DLQ, GRM, and SS. All indicators were first standardized using z-scores to have a comparable scale:

$$Z_X = \frac{X - \mu}{\sigma}$$

Next, the LDGS Index was calculated as the average z-score value:

$$LDGS_Z = \frac{Z_{LQ} + Z_{DLQ} + Z_{GRM} + Z_{SS}}{4}$$

This index comprehensively represents the dynamic performance of the industrial sector and human resource distribution across regions and time.

Klassen Typology

The Klassen typology is used to classify districts/cities based on the level of contribution and growth rate of the industrial sector, resulting in four regional categories:

a. Prime sector,
b. Potential sector,
c. Developing sector, and
d. Underdeveloped sector.

The determination of a sector's category into the four categories above is based on the growth rate of sectoral contribution and the average size of sectoral contribution to the GRDP, as shown in the following matrix:

Table 1. Klassen Typology Matrix.

Average Sectoral Growth Rate	Average Sectoral Contribution to GRDP	
	$Y_{sektor} >= Y_{GRDP}$	$Y_{sektor} <= Y_{GRDP}$
$r_{sektor} >= r_{GRDP}$	Primary Sector	Developing Sector
$r_{sektor} <= r_{GRDP}$	Potential Sector	Underdeveloped Sector

Source : (Widodo, 2006).

Description:

Y_{sektor} = contribution value of sector i

Y_{GRDP} = average GRDP

r_{sektor} = growth rate of sector i

r_{GRPD} = GRDP growth rate

Spatial Analysis: Moran's I and LISA

Spatial analysis is used to identify patterns of dependence and spatial clusters of industrial sector human resource dynamics between districts/cities. The approaches used include Global Moran's I and Local Indicators of Spatial Association (LISA).

Global Moran's I is used to test for the presence of overall spatial autocorrelation, with the formula:

$$I = \frac{n}{W} \frac{\sum_i \sum_j w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}$$

A positive Moran's I value indicates a cluster pattern (high–high or low–low), while a negative value indicates a dispersion pattern. Furthermore, LISA analysis is used to identify local clusters, which are areas with the following characteristics:

a. High–High (developed areas surrounded by developed areas),
b. Low–Low (underdeveloped areas surrounded by underdeveloped areas),
c. High–Low and Low–High (regions with deviating characteristics).

This analysis enables the identification of priority regions in the development of spatially-based industrial human resources.

Research Workflow

a. Overall, this research workflow consists of:
b. Calculation of basic indicators (LQ, DLQ, GRM, SS),
c. Standardization of indicators and formation of the LDGS Index,

d. Classification of regions using Klassen's Typology,

e. Spatial analysis using Moran's I and LISA.

Framework

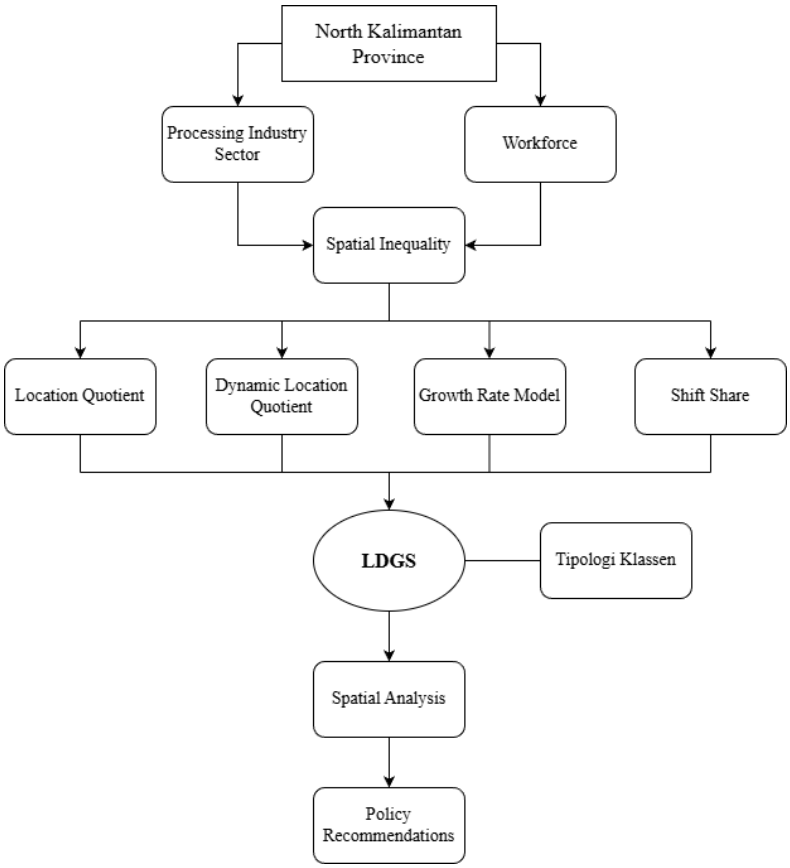

Figure 4. Conceptual Framework.

3. RESULTS AND DISCUSSION

Spatial Distribution of Industrial Labor Concentration

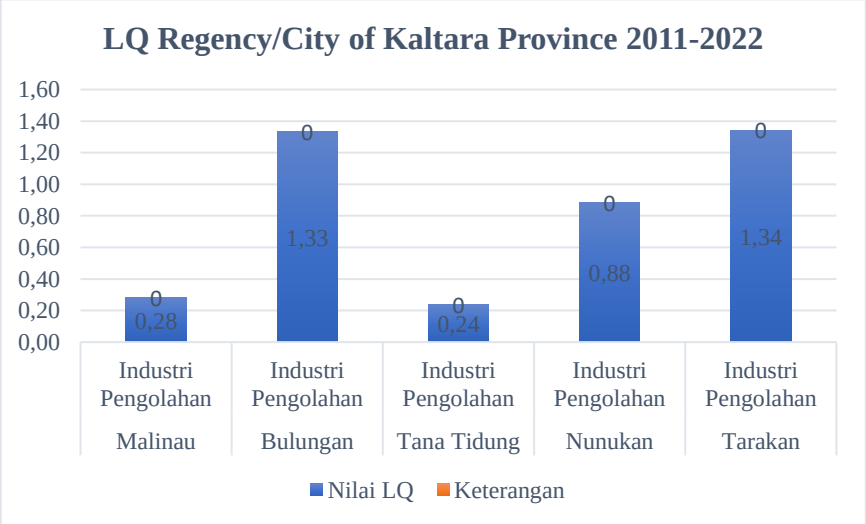

Figure 5. LQ Analysis of Regencies and Cities in Kaltara Province 2011-2022.

The results of the Location Quotient (LQ) analysis reveal a highly uneven spatial distribution of industrial labor concentration across regencies and municipalities in North Kalimantan Province during the period 2011–2022. The estimated LQ values indicate clear differences in the degree of specialization of the manufacturing sector among regions, suggesting the existence of spatial disparities in the role of industry as a driver of local labor absorption.

Among the observed regions, Tarakan City (LQ = 1.34) and Bulungan Regency (LQ = 1.33) exhibit LQ values consistently greater than unity, indicating that the manufacturing sector in these areas functions as a basic sector with a relatively higher concentration of industrial labor compared to the provincial average. This finding suggests that both regions possess a stronger industrial specialization, supported by better infrastructure, market accessibility, and urban economic agglomeration, which collectively enhance their capacity to attract and absorb industrial labor.

In contrast, Nunukan Regency (LQ = 0.88) shows an LQ value slightly below one, implying that although the manufacturing sector plays a notable role in the local economy, it has not yet reached the level of specialization observed in Tarakan and Bulungan. This condition indicates a transitional industrial structure, where manufacturing activity exists but remains secondary relative to other sectors or is constrained by limited industrial depth and labor productivity.

Meanwhile, Malinau Regency (LQ = 0.28) and Tana Tidung Regency (LQ = 0.24) record substantially lower LQ values, reflecting a weak industrial labor base in these regions. The manufacturing sector in these areas is not a leading contributor to employment and remains marginal within the overall economic structure. Such low LQ values suggest structural constraints, including limited industrial infrastructure, lower human capital readiness, and stronger dependence on primary sectors.

Overall, the LQ results demonstrate that industrial labor concentration in North Kalimantan is spatially polarized, with industrial activities and employment clustered in a small number of urban and administrative centers, while peripheral regions lag significantly behind. This spatial imbalance underscores the importance of adopting region-specific industrial and human resource development policies, as uniform policy interventions may not adequately address the heterogeneous industrial capacities across regions.

Importantly, these findings provide a critical baseline for subsequent analyses using DLQ, GRM, Shift Share, and the composite LDGS index. While LQ captures the static dimension of industrial labor concentration, further analysis is required to assess whether

regions with high specialization also exhibit dynamic growth, competitive advantages, and positive spatial spillovers over time.

Temporal Dynamics of Industrial Specialization

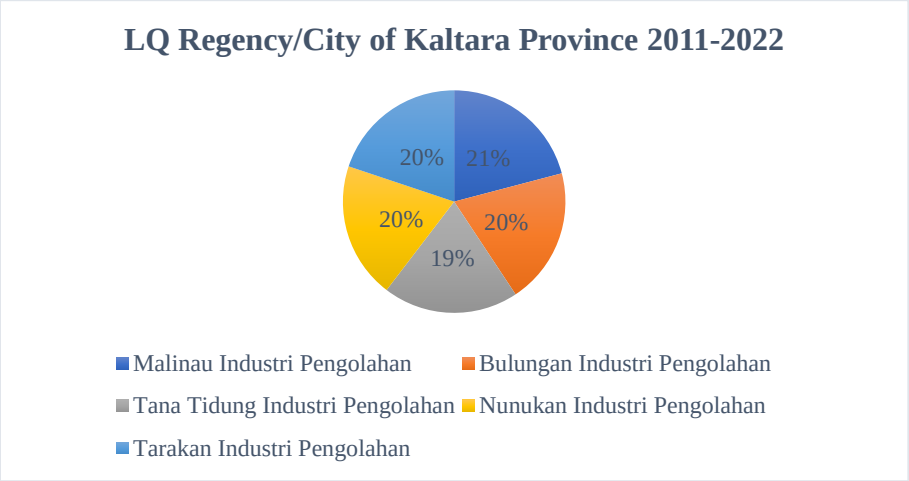

Figure 6. DLQ Analysis of Regencies and Cities in Kaltara Province 2011-2022.

The Dynamic Location Quotient (DLQ) analysis provides insights into the temporal evolution of industrial specialization across regencies and municipalities in North Kalimantan Province during the period 2011–2022. Unlike static LQ, DLQ captures whether the relative concentration of industrial labor in each region is strengthening or weakening over time compared to the provincial benchmark.

The results indicate that the DLQ values are relatively evenly distributed across regions, with proportions ranging between approximately 19% and 21%. This pattern suggests that no single regency or municipality dominates the dynamic evolution of industrial specialization during the observed period. Instead, the manufacturing sector across North Kalimantan exhibits a moderate and broadly balanced temporal adjustment, reflecting a shared trajectory of industrial development rather than highly polarized dynamics.

Regions such as Malinau and Tarakan show slightly higher DLQ shares (around 21% and 20%, respectively), indicating a marginal strengthening of industrial specialization over time. This suggests that, although these regions may not always exhibit the highest static concentration levels, they demonstrate a gradual improvement in their relative industrial positioning. Such dynamics may be associated with incremental investments, improvements in labor absorption capacity, or gradual diversification within the manufacturing sector.

In contrast, Tana Tidung, with the lowest DLQ proportion (approximately 19%), reflects a weaker temporal dynamic, implying that industrial specialization in this region has grown more slowly or has remained relatively stagnant over the study period. Meanwhile, Bulungan and Nunukan, each accounting for about 20%, indicate relatively stable dynamics,

where changes in industrial concentration neither significantly outpaced nor lagged behind the provincial trend.

Overall, the DLQ results suggest that industrial specialization in North Kalimantan is not undergoing sharp spatial divergence over time, but rather evolving through incremental and relatively uniform changes across regions. This finding implies that while static disparities in industrial concentration remain evident (as shown by LQ), the temporal dynamics of specialization do not significantly exacerbate these disparities.

Importantly, these results highlight that regions with low initial LQ values do not necessarily experience rapid catch-up in industrial specialization, nor do regions with high LQ values consistently reinforce their dominance. Therefore, DLQ underscores the need to complement static concentration analysis with growth and competitiveness indicators, such as GRM and Shift Share, to better understand whether temporal changes in industrial specialization translate into sustained economic advantages. This dynamic perspective provides a critical linkage toward the construction of the composite LDGS index in subsequent analysis.

Comparative Growth Performance of the Industrial Sector

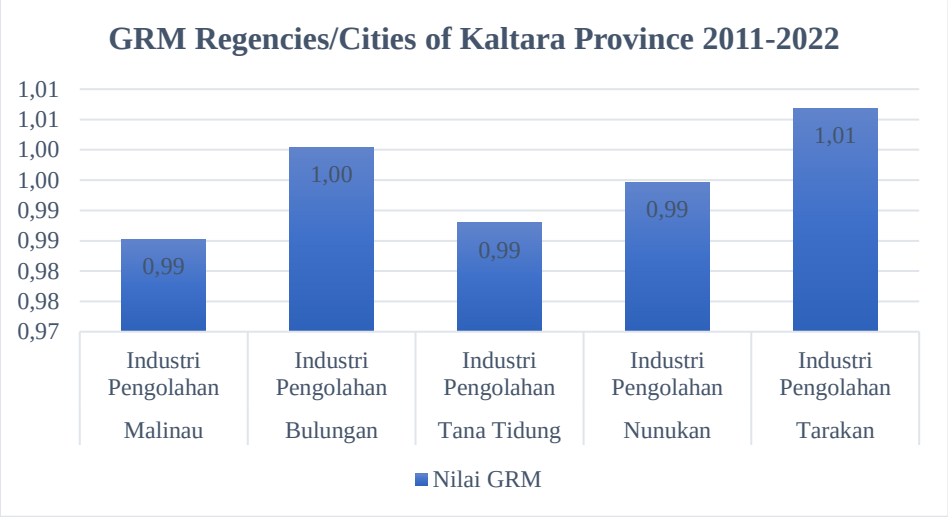

Figure 7. GRM Analysis of Regencies and Cities in Kaltara Province 2011-2022.

The Growth Rate Model (GRM) analysis provides evidence on whether the manufacturing sector in each regency/municipality of North Kalimantan Province has grown faster or slower relative to the provincial benchmark during the period 2011–2022. The results indicate that interregional differences in industrial growth performance are relatively small, with GRM values clustered closely around unity.

As shown in Figure 7, Tarakan City records the highest GRM value (1.01), indicating that the growth rate of its manufacturing sector slightly outpaced the provincial average. This suggests that Tarakan not only functions as an important industrial center in terms of concentration, but also demonstrates a marginal growth advantage, likely supported by better infrastructure, market accessibility, and stronger agglomeration economies.

Bulungan Regency exhibits a GRM value equal to the provincial benchmark (1.00), implying that industrial growth in this region closely follows the overall provincial trend. This result indicates a stable growth trajectory, where industrial expansion neither significantly accelerates nor lags behind the provincial average.

In contrast, Malinau Regency, Tana Tidung Regency, and Nunukan Regency show GRM values slightly below unity (approximately 0.99). These values indicate that industrial growth in these regions has been marginally slower than the provincial average. Although the deviations are relatively small, they nonetheless suggest structural constraints that may limit the pace of industrial expansion, such as weaker industrial linkages, limited scale of production, or lower productivity of industrial labor.

Overall, the narrow range of GRM values (0.99–1.01) implies that industrial growth across North Kalimantan has progressed in a broadly uniform manner, without sharp divergence among regions. However, this apparent balance in growth performance masks important structural differences. Regions with higher growth rates do not necessarily experience rapid industrial transformation, while regions with lower growth rates may still expand in absolute terms due to their initial industrial base.

When interpreted in conjunction with the LQ and DLQ results, the GRM findings reveal a critical insight: higher industrial concentration does not automatically translate into significantly faster growth, and conversely, regions with weaker industrial bases are not experiencing accelerated catch-up. This decoupling between growth performance and structural specialization underscores the limitation of relying solely on growth indicators to assess regional industrial competitiveness.

Therefore, the GRM results reinforce the need for an integrated analytical framework, such as the composite LDGS index, which combines growth performance with concentration, temporal dynamics, and competitiveness indicators. Such an approach enables a more comprehensive understanding of the spatial dynamics of industrial development and human resource distribution in North Kalimantan Province.

Sources of Regional Industrial Growth and Competitiveness

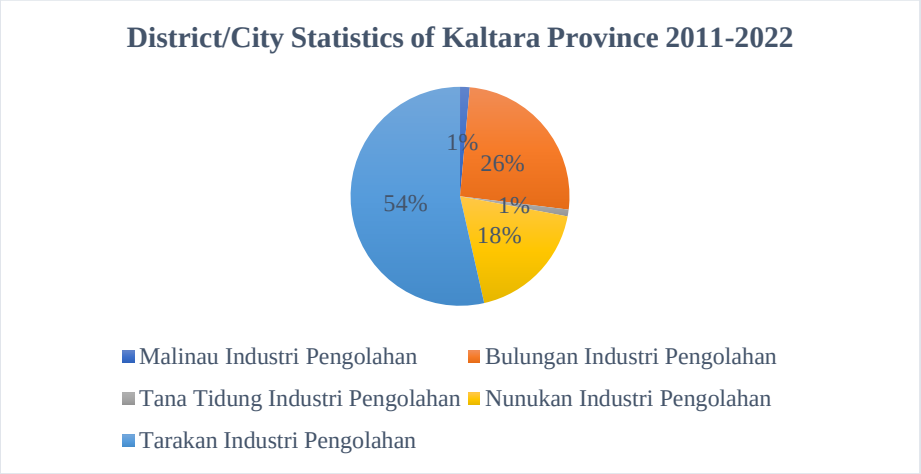

Figure 8. SS Analysis of Regencies and Cities in Kaltara Province 2011-2022.

The Shift Share Analysis (SSA) provides insights into the underlying sources of industrial growth and regional competitiveness across regencies and municipalities in North Kalimantan Province during the period 2011–2022. By decomposing industrial growth into national growth effects, industry mix effects, and regional competitive effects, this analysis enables a more nuanced understanding of whether regional performance is driven primarily by external macroeconomic forces or by localized competitive advantages.

The results reveal a highly uneven contribution of competitive effects across regions, indicating substantial spatial disparities in industrial competitiveness. Tarakan City accounts for the largest share of the competitive effect (approximately 54%), highlighting its dominant role as the primary driver of regional industrial competitiveness in North Kalimantan. This strong competitive share suggests that industrial growth in Tarakan is not merely a reflection of national or provincial trends, but rather the result of localized advantages, such as superior infrastructure, stronger agglomeration economies, better market connectivity, and more productive industrial labor.

Bulungan Regency contributes around 26% of the competitive effect, indicating a moderate but significant level of regional competitiveness. This result implies that Bulungan benefits from certain localized strengths, possibly administrative functions, proximity to provincial governance centers, or developing industrial linkages, that allow its manufacturing sector to perform better than would be expected based solely on national growth trends.

In contrast, Nunukan Regency accounts for approximately 18% of the competitive effect, suggesting a limited but emerging regional advantage. While the manufacturing sector in Nunukan shows some degree of competitiveness, its contribution remains constrained, potentially due to structural challenges such as limited industrial depth, logistical constraints,

or dependence on cross-border economic dynamics that have not yet fully translated into sustained industrial competitiveness.

Meanwhile, Malinau Regency and Tana Tidung Regency contribute only marginally (around 1% each) to the competitive component of industrial growth. These negligible shares indicate that industrial growth in these regions is largely driven by external or structural factors, rather than by endogenous regional competitiveness. The absence of a significant competitive effect suggests weak industrial linkages, limited scale economies, and insufficient human capital specialization to support competitive industrial expansion.

Overall, the Shift Share results demonstrate that industrial growth and competitiveness in North Kalimantan are spatially concentrated, with a small number of regions, particularly Tarakan and, to a lesser extent, Bulungan, capturing the majority of competitive advantages. This pattern reinforces earlier findings from the LQ and GRM analyses, where regions with stronger industrial bases tend to exhibit superior competitive performance, while peripheral regions remain structurally constrained.

Importantly, the dominance of the competitive effect in Tarakan underscores the presence of spatially asymmetric development dynamics, where growth benefits are not evenly distributed across regions. These findings highlight the need for region-specific industrial and human resource development policies, particularly in lagging regions, to strengthen local competitiveness and reduce long-term spatial disparities.

When integrated into the composite LDGS framework, the Shift Share results provide critical evidence that regional competitiveness, rather than growth alone, plays a decisive role in shaping the spatial dynamics of industrial development and labor distribution in North Kalimantan Province.

Composite LDGS Index and Regional Classification

Table 2. LDGS Analysis of Regencies/Cities in Kaltara Province.

Regencies/Cities in Kaltara Province	Sector	Value						Value		
		LQ	DLQ	GRM	SS	Z_LQ	Z_DLQ	Z_GRM	Z_SS	Z_LDGS
Malinau	Processing Industry	0,28	0,99	2920,59	1,07	-1,03	-0,55	-0,50	-0,09	-0,55
Bulungan	Processing Industry	1,33	1,00	52346,75	1,02	0,80	0,10	0,30	-0,17	0,26
Tana Tidung	Processing Industry	0,24	0,99	2050,25	1,01	-1,11	-0,43	-0,52	-0,18	-0,56
Nunukan	Processing Industry	0,88	0,99	37977,73	1,01	0,01	-0,15	0,07	-0,17	-0,06

Tarakan	Processing Industry	1,34	1,01	109823,62	1,02	0,82	0,37	1,24	-0,16	0,57

The composite LDGS index provides an integrated assessment of regional industrial performance by synthesizing four key dimensions: industrial labor concentration (LQ), temporal dynamics of specialization (DLQ), relative growth performance (GRM), and regional competitiveness (Shift Share). By standardizing these indicators using *z-scores*, the LDGS index allows for a comparative and balanced evaluation of regional performance, overcoming the limitations of single-indicator analyses.

The results reveal substantial interregional disparities in the dynamic performance of the manufacturing sector across regencies and municipalities in North Kalimantan Province.

Tarakan City emerges as the strongest-performing region, recording the highest composite LDGS score (Z_LDGS = 0.57). This positive index value reflects a consistent combination of above-average industrial concentration (Z_LQ = 0.82), strong temporal dynamics (Z_DLQ = 0.37), and particularly exceptional growth performance (Z_GRM = 1.24). Although the competitive shift component (Z_SS = −0.16) is slightly below the provincial mean, Tarakan's overall performance is driven by its superior growth capacity and sustained industrial specialization. Within the Klassen typology framework, Tarakan can therefore be classified as a leading (advanced and rapidly growing) industrial region, functioning as the primary growth pole of manufacturing-based employment in the province.

Bulungan Regency occupies an intermediate but positive position, with a composite LDGS score of Z_LDGS = 0.26. This outcome is supported by above-average industrial concentration (Z_LQ = 0.80) and moderate positive growth dynamics (Z_GRM = 0.30), while DLQ remains close to the provincial average (Z_DLQ = 0.10). However, the slightly negative competitive shift (Z_SS = −0.17) suggests that Bulungan's industrial expansion is driven more by structural and growth factors than by strong localized competitiveness. In the Klassen typology, Bulungan can be categorized as a potential region, characterized by a solid industrial base but requiring further strengthening of endogenous competitive advantages to transition into the leading group.

In contrast, Nunukan Regency exhibits a slightly negative composite LDGS value (Z_LDGS = −0.06), indicating a marginally below-average dynamic industrial performance. While Nunukan shows relatively neutral scores in industrial concentration (Z_LQ = 0.01) and growth (Z_GRM = 0.07), its weak specialization dynamics (Z_DLQ = −0.15) and negative competitive effect (Z_SS = −0.17) constrain its overall performance. According to the Klassen framework, Nunukan may be classified as a developing region, where industrial activity exists

but lacks sufficient momentum to generate sustained competitiveness and dynamic upgrading of industrial labor.

Malinau Regency and Tana Tidung Regency represent the lowest-performing regions, with composite LDGS scores of −0.55 and −0.56, respectively. Both regions exhibit consistently negative standardized values across almost all indicators, particularly in industrial concentration (Z_LQ = −1.03 for Malinau; −1.11 for Tana Tidung) and growth dynamics (Z_GRM = −0.50 and −0.52, respectively). These results indicate that manufacturing activities in these regions remain structurally weak, characterized by limited labor absorption, low growth capacity, and the absence of competitive advantages. Within the Klassen typology, Malinau and Tana Tidung are therefore classified as lagging regions, where industrial development has yet to become a meaningful driver of regional economic transformation.

Overall, the LDGS-based classification highlights a clear spatial hierarchy in industrial development and human resource dynamics within North Kalimantan Province. Industrial performance is highly concentrated in Tarakan, moderately supported in Bulungan, weakly developing in Nunukan, and structurally constrained in Malinau and Tana Tidung. These findings underscore the importance of differentiated, region-specific industrial and human resource policies, as uniform development strategies are unlikely to address the heterogeneous capacities and challenges across regions.

Importantly, the LDGS results validate the analytical advantage of using a composite, dynamic, and spatially sensitive index, as they reveal structural disparities that would remain obscured if analysis relied solely on single indicators such as growth or concentration. This integrated perspective provides a robust empirical foundation for the subsequent spatial clustering analysis and policy discussion.

Spatial Autocorrelation and Local Clustering of LDGS

Table 4. Analysis Moran's I & LISA.

No.	Regencies/Cities of Kaltara Province	Z_LDGS
1.	Malinau	-0,55
2.	Bulungan	0,26
3.	Tana Tidung	-0,56
4.	Nunukan	-0,06
5.	Tarakan	0,57

Spatial autocorrelation analysis is employed to examine whether the spatial distribution of the composite LDGS index across regencies and municipalities in North Kalimantan Province exhibits systematic spatial dependence or follows a random pattern. This analysis is

conducted using Global Moran's I to assess overall spatial autocorrelation and Local Indicators of Spatial Association (LISA) to identify localized clustering patterns.

Based on the spatial distribution of the standardized LDGS values, the results indicate a non-random spatial pattern in the dynamic performance of the manufacturing sector and industrial labor across regions. The observed LDGS values reveal a clear contrast between positive-performing regions such as Tarakan City (LDGS_Z = 0.57) and Bulungan Regency (LDGS_Z = 0.26) and negative-performing regions, including Malinau (−0.55) and Tana Tidung (−0.56), with Nunukan (−0.06) occupying an intermediate position.

The Global Moran's I analysis confirms the presence of spatial autocorrelation in LDGS values, indicating that regions with similar levels of dynamic industrial performance tend to be spatially proximate. This finding suggests that regional industrial dynamics and human resource performance are influenced not only by internal characteristics but also by spatial spillover effects from neighboring regions.

Tabel 5. Analysis LISA.

No.	Regencies/Cities of Kaltara Province	LISA
1.	Malinau	LL
2.	Bulungan	HH
3.	Tana Tidung	LL
4.	Nunukan	LH/HL
5.	Tarakan	HH

Further insights are provided by the LISA analysis, which identifies local clusters of industrial performance. The results indicate the emergence of a high–high (HH) cluster, centered on Tarakan City, which is spatially associated with relatively higher-performing neighboring regions such as Bulungan Regency. This cluster represents a localized growth pole characterized by strong industrial concentration, favorable growth dynamics, and relatively superior human resource performance.

Conversely, low–low (LL) clustering patterns are observed in inland and peripheral regions, particularly Malinau and Tana Tidung, where negative LDGS values are spatially reinforced by adjacency to similarly underperforming regions. This pattern indicates the presence of spatially entrenched structural disadvantages, where limited industrial bases, weaker labor absorption, and low competitiveness mutually reinforce each other across neighboring territories.

Nunukan Regency, with an LDGS value close to zero, does not form a strong local cluster but instead occupies a transitional spatial position, potentially classified as a low–high (LH) or high–low (HL) area depending on the characteristics of adjacent regions. This suggests

that Nunukan may be influenced by both positive spillovers from more dynamic regions and negative pressures from structurally weaker neighbors.

Overall, the Moran's I and LISA results demonstrate that spatial proximity plays a significant role in shaping the distribution of industrial performance and human resource dynamics in North Kalimantan Province. The existence of distinct high-performing and low-performing clusters indicates that regional disparities are not isolated phenomena but are spatially interconnected.

These findings have important policy implications. The dominance of high–high clustering around Tarakan suggests that industrial development strategies should leverage spatial spillover mechanisms, such as interregional labor mobility, industrial linkages, and infrastructure connectivity. At the same time, persistent low–low clusters highlight the need for targeted, place-based interventions to prevent the spatial entrenchment of underdevelopment in lagging regions.

Importantly, the spatial clustering of LDGS values further validates the analytical strength of the composite LDGS framework, as it captures not only interregional differences but also their spatial interdependencies, which would remain obscured under non-spatial analytical approaches.

Reconciling Klassen Typology and LDGS Results

Table 6. Analysis Tipology Klassen.

Average Sectoral Growth Rate	Average Sectoral Contribution to GRDP	
	$Y_{sektor} >= Y_{GRDP}$	$Y_{sektor} <= Y_{GRDP}$
$r_{sektor} >= r_{GRDP}$	Kabupaten Bulungan Kota Tarakan	-
$r_{sektor} <= r_{GRDP}$	-	Kabupaten Malinau Kabupaten Nunukan Kabupaten Tana Tidung

The comparison between the Klassen Typology and the composite LDGS–LISA framework reveals conceptual complementarity rather than methodological inconsistency. Although both approaches are used to classify regional economic performance, they differ fundamentally in analytical focus, temporal orientation, and spatial sensitivity.

The Klassen Typology provides a static structural classification, relying on average sectoral contribution and growth rates to position regions within a four-quadrant typology. This approach is effective in identifying whether a sector currently functions as a leading or lagging component of the regional economy. In contrast, the LDGS framework offers a dynamic and spatially sensitive assessment, integrating standardized measures of industrial concentration,

specialization dynamics, growth performance, and regional competitiveness, and further contextualized through spatial clustering analysis.

In this study, Bulungan Regency is classified as a prime sector under the Klassen Typology due to its above-average contribution and growth in the manufacturing sector. This classification is reinforced but spatially refined by the LDGS–LISA results, which show that Bulungan is part of a high–high (HH) spatial cluster centered on Tarakan City. This indicates that Bulungan's industrial performance is supported not only by its internal structural strengths but also by positive spatial spillovers from the provincial growth pole.

Conversely, Nunukan Regency is categorized as a lagging sector under the Klassen Typology, reflecting its below-average contribution and growth in a static sense. However, the LDGS results place Nunukan slightly below the provincial average, suggesting that while its manufacturing sector is structurally weak, it exhibits characteristics of a developing region rather than a stagnant one. This distinction highlights the added value of the LDGS framework in capturing latent dynamics and transitional trajectories that are not observable through static typological approaches.

Overall, the apparent differences in regional classification arise from the distinct analytical lenses employed by each method. Rather than contradicting each other, the Klassen Typology and LDGS–LISA framework jointly provide a more comprehensive understanding of regional industrial development by distinguishing between current structural position and dynamic performance potential. This integrated perspective strengthens the robustness of the empirical findings and enhances their relevance for spatially differentiated policy formulation.

4. CONCLUSION AND RECOMMENDATIONS

This study examines the spatial dynamics of human resources in the manufacturing sector of North Kalimantan Province by developing and applying a composite LDGS index, which integrates Location Quotient, Dynamic Location Quotient, Growth Rate Model, and Shift Share Analysis, and is further reinforced through Klassen Typology and spatial autocorrelation analysis (Moran's I and LISA). By combining static, dynamic, and spatial perspectives, this research provides a comprehensive assessment of regional industrial performance that goes beyond conventional single-indicator approaches.

The empirical results demonstrate that the distribution of industrial labor in North Kalimantan is structurally uneven and spatially polarized. Static analysis using LQ reveals that manufacturing activities are concentrated primarily in Tarakan City and Bulungan Regency, while Malinau and Tana Tidung remain structurally weak with limited industrial

labor absorption. Temporal analysis using DLQ indicates that industrial specialization across regions evolves in a relatively uniform manner, suggesting persistence of existing structural disparities rather than strong convergence or divergence over time. Similarly, GRM results show near-convergent growth performance across regions, implying that comparable growth rates do not necessarily translate into structural upgrading in lagging areas.

More decisive insights emerge from the Shift Share and LDGS analyses. The competitive component of industrial growth is highly concentrated, with Tarakan acting as the dominant regional growth pole, followed by Bulungan. The composite LDGS index confirms a clear hierarchy of regional industrial performance: Tarakan as a leading region, Bulungan as a potential region, Nunukan as a developing region, and Malinau and Tana Tidung as lagging regions. These findings highlight that regional competitiveness and specialization dynamics, rather than growth alone, play a critical role in shaping spatial inequalities in industrial human resource development.

Spatial analysis using Moran's I and LISA further confirms that these disparities are not randomly distributed, but instead form distinct high–high (HH) and low–low (LL) clusters. Tarakan and Bulungan constitute a high-performing cluster characterized by positive spillovers, while Malinau and Tana Tidung form a low-performing cluster where structural disadvantages are spatially reinforced. Nunukan occupies a transitional position, reflecting both constraints and latent development potential.

Taken together, the findings validate the analytical advantage of the LDGS framework as a dynamic, integrative, and spatially sensitive tool for assessing regional industrial development and human resource dynamics. The integration of Klassen Typology with LDGS–LISA further demonstrates that static structural classifications and dynamic–spatial assessments are complementary, allowing for a more nuanced understanding of regional trajectories and policy needs.

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