Leading sectors, multiplier effects, and economic spillovers among the islands of East Nusa Tenggara Province

Werenfridus Taena[1*]; Anggelina Delviana Klau[2]; Marce Sherly Kase[2]; Fried Markus Alung Blegur[3]; Felisisima Afoan[4]; Febrya Christin Putri Handayani Buan[3]

[1)] Agribusiness Study Program, Faculty of Agriculture, Universitas Timor, Indonesia
[2)] Development Economics Study Program, Faculty of Economics and Business, Universitas Timor, Indonesia
[3)] Mathematics Study Program, Faculty of Agriculture, Science, and Health, Universitas Timor, Indonesia
[4)] Management Study Program, Faculty of Economics and Business, Universitas Timor, Indonesia

**To whom correspondence should be addressed. Email: weren_ntt@yahoo.co.id*

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Abstract

Regional economic disparities and fragmented inter-island linkages remain key challenges in East Nusa Tenggara (NTT), one of Indonesia's archipelagic provinces with diverse resource endowments. This study analyzes the structure and dynamics of NTT's regional economy by identifying its leading sectors through intersectoral linkage analysis, estimating the magnitudes of multiplier effects, and examining spillover effects across the province's major islands. The research utilizes the 2016 Input–Output Table of NTT Province and the accumulated Gross Regional Domestic Product (GRDP) data of regencies and cities across the Timor, Flores, and Sumba islands for the 2016–2023 period. Analytical methods include linkage analysis, multiplier effect estimation, and the Vector Error Correction Model (VECM). The results show that agriculture, manufacturing, electricity, trade, and transportation constitute the leading sectors due to their strong forward and backward linkages. At the same time, agriculture and manufacturing also generate the largest multiplier effects. These sectors further create significant inter-island spillover effects, characterized by spread effects between Sumba–Timor, Sumba–Flores, and Timor–Sumba, and backwash effects between Timor–Flores and Flores–Sumba. The findings highlight that strengthening productive linkages in agriculture and manufacturing is vital for enhancing spatial equity and promoting inclusive regional growth. Conceptually, this study contributes to the literature by integrating intersectoral, multiplier, and spillover analyses to explain spatial economic interdependence in archipelagic regions and by offering practical policy implications for fostering sustainable inter-island integration in NTT Province.

Keywords: *Input–Output analysis; Leading sectors; Multiplier effects; Spillover effects; Regional economy*

JEL Classification: O18, R11, R12, R15

INTRODUCTION

Each region possesses different potentials due to variations in natural and social factors. Differences in economic potential can be identified through the economic activities in a region. The value of these activities is recorded in the Gross Regional Domestic Product (GRDP). According to Suripto & Lestari (2019), the value of economic activities reflected in the GRDP forms the economic structure of each region.

The economy of East Nusa Tenggara Province (NTT) is dominated by the agricultural sector, which contributed approximately 29% in 2021, 2022, and 2023 (BPS NTT, 2024). The agricultural sector carries a significant burden, accounting for up to 51% of the workforce, indicating a concentration of labor in this sector compared to other economic sectors in NTT. Izuchukwu (2015) and Mardalena et al. (2019) explain that the agricultural sector provides the highest employment opportunities and labor absorption. This sector also drives industrialization, as the majority of industrial inputs in NTT originate from agricultural products. This indicates strong intersectoral linkages within the regional economy, thereby stimulating economic growth.

The interlinkages among economic sectors exert a greater impact through the economic multiplier effect. An increase in final demand in one sector not only raises the demand for inputs in that sector but also stimulates activity in other sectors. The multiplier effect of a leading sector is expected to be stronger than that of other sectors, thereby generating greater benefits for regional economic development. Leading sectors play an important role in labor absorption and in promoting economic growth—both directly and through multiplier effects—while also enhancing regional connectivity and reducing regional disparities. Baransano et al. (2016) state that leading sectors serve as engines of growth that help diminish regional inequality.

The distribution of leading sectors across districts and cities in NTT influences both overall economic growth and the economic performance of the province's islands. According to the 2011–2030 NTT Provincial Spatial Plan, island development priorities are based on each island's potential. The Flores Islands region is prioritized for the development of horticultural and plantation commodities, while Timor and Sumba are prioritized for food crop and livestock development. This inter-island specialization creates a spillover effect driven by product supply and demand between islands. Das et al. (2022) note that spillover effects occur in both upstream and downstream segments of production and distribution networks, within and beyond regional boundaries. Similarly, Zamani and Tayebi (2021) argue that spillover effects within economic cooperation areas arise through technology transfer, playing a crucial role in fostering economic growth, capital accumulation, and welfare—thereby paving the way for sustainable development.

Previous studies have explored regional development from various perspectives, such as identifying leading sectors through input–output linkages (Kilateng et al., 2017; Logaritma, 2022), estimating the magnitude of multiplier effects to measure inter-sectoral interdependence (Puspita & Ningsih, 2021; Koylal et al., 2023; Ciaffi et al., 2024), and analyzing spillover dynamics across regions (Huo & Ahmed, 2017; Ashfaq et al., 2020; Qibti & Hendarto, 2020). However, these approaches have largely been applied in isolation—focusing either on sectoral strengths, transmission mechanisms, or spatial interactions. What remains underexplored is how leading sectors with strong multiplier effects contribute to inter-island spillover processes within a multi-island regional economy.

Integrating these three perspectives provides a more holistic framework to understand how sectoral linkages translate into spatial economic diffusion, particularly in archipelagic regions such as East Nusa Tenggara (NTT). This study contributes to the

regional development literature by empirically combining inter-sectoral linkage, multiplier, and spillover analyses to explain inter-island economic interdependence in a multi-island context. Accordingly, this study aims to identify the leading sectors in NTT Province using an intersectoral economic linkage approach, examine the economic multipliers, and evaluate how these factors influence spillover effects across the islands of NTT Province.

METHODS

Type and source of data

This study employs secondary data, consisting of the Input-Output (I–O) Table of East Nusa Tenggara (NTT) Province for 2016 (BPS NTT Province, 2024), as well as the GRDP data of NTT Province and the GRDP of its regencies/cities for the period 2016–2023. The 2016 I–O data from BPS NTT Province were used since the province's economic structure remained relatively stable between 2016 and 2023, making the 2016 I–O table (in transaction form) suitable for the analysis.

Data analysis

Data analysis begins with forward and backward linkage analysis and the standardization of linkage values, which are then used as inputs in the Klassen typology analysis to identify the leading sectors. The analysis continues with a multiplier analysis to identify the economic sectors with the highest multipliers. Sectors in the 85th percentile are categorized as leading sectors and as those producing the largest multiplier effects.

The leading sectors and sectors with the highest multiplier effects for each island and major archipelago in NTT Province are further tested to determine whether spillover effects occur across islands using spillover effect analysis. The analytical framework is illustrated in Figure 1.

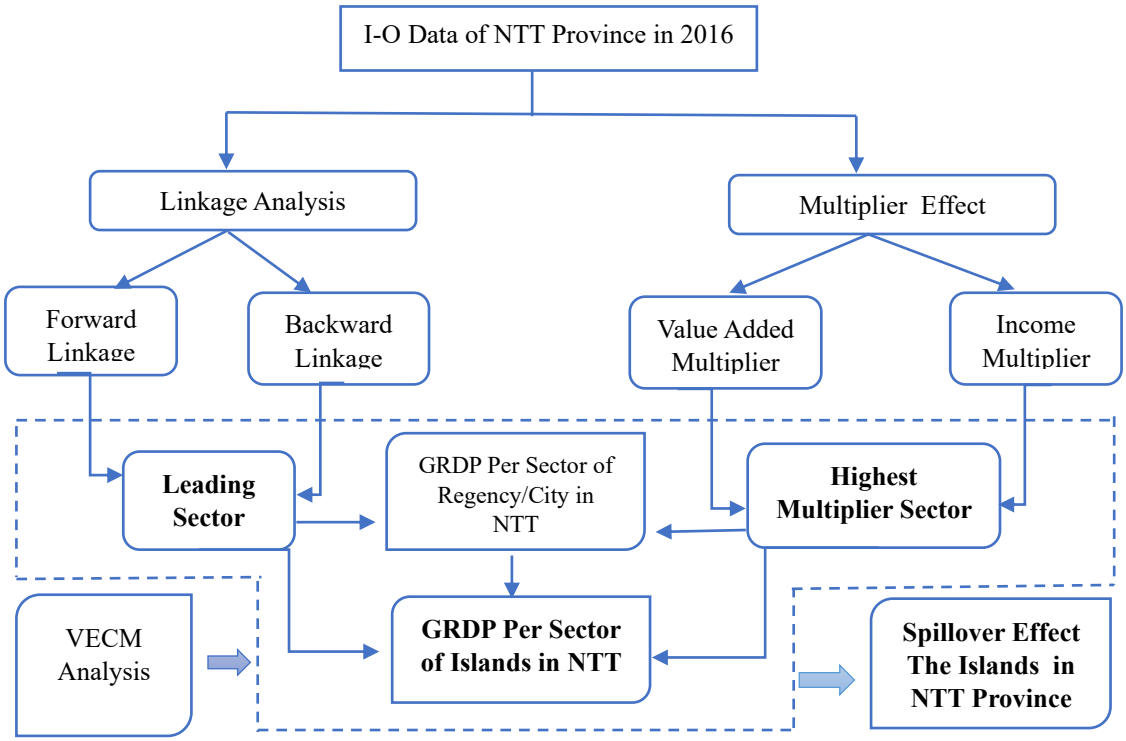

Figure 1. Data analysis flowchart

Leading sector identification

Leading sector identification is conducted in two stages. Stage 1 analyzes sectoral linkages, including direct forward linkages and direct and indirect backward linkages. The linkage values are then standardized for subsequent analysis. Stage 2 applies the Klassen Typology, which groups sectors into four quadrants. Following Fafurida (2012) and Nugroho (2021), sectors with forward and backward linkage values greater than 1 are classified as leading sectors.

Linkage analysis

Following Rasmussen (1956) and Hirschman (1958), linkage analysis identifies key sectors based on their ability to stimulate other sectors (forward linkages) and their dependence on inputs from other sectors (backward linkages). Both forward and backward linkages are grouped into direct and indirect linkages.

a. <u>Direct forward linkage</u>

Forward linkages show the impact of a particular sector on sectors that use part of its output directly, for each unit increase in total demand. United Nations (1999), Nazara (2005), and Suripto & Lestari (2019) state the formulation as:

$$F_i^{(d)} = \sum_{j=1}^{n} a_{ij} \quad \text{(1)}$$

$F_i^{(d)}$: direct forward linkage of sector i; a_{ij}: coefficient matrix; n: number of sectors.

<u>b. Direct and indirect forward linkage</u>

Direct and indirect forward linkages show the impact of a particular sector on sectors that use its output directly or indirectly for each unit increase in total demand (UN, 1999; Hartono et al., 2007; Marconi, 2016). The mathematical formula is as follows:

$$F_i^{(d+i)} = \sum_{j=1}^{n} \alpha_{ij} \quad \text{(2)}$$

$F_i^{(d+i)}$: direct and indirect forward linkage of sector i; α_{ij}: Leontief inverse matrix; n: number of sectors.

<u>c. Direct backward linkage</u>

Backward linkages show the impact of a particular sector on sectors that provide it with intermediate inputs, for each unit increase in total demand. I–O analysis is comprehensive because it measures both forward and backward linkages for each economic sector (United Nations, 1999; Cahyono & Sumargo, 2005; Armelly et al., 2022). The direct backward linkage formula is:

$$B_j^{(d)} = \sum_{i=1}^{n} a_{ij} \quad \text{(3)}$$

$B_j^{(d)}$: direct backward linkage of sector j; a_{ij}: coefficient matrix; n: number of sectors.

<u>d. Direct and indirect backward linkage</u>

Direct and indirect backward linkages show the impact of a particular sector on sectors that provide intermediate inputs to it either directly or indirectly per unit increase in total demand (UN, 1999; Hartono et al., 2007; Jannah & Tasriah, 2022). The direct and indirect backward linkage formula is:

$$B_j^{(d+i)} = \sum_{i=1}^{n} \alpha_{ij} \quad (4)$$

$B_j^{(d+i)}$: direct and indirect backward linkage of sector j; α_{ij}: Leontief inverse matrix; n: number of sectors.

Klassen tipology application

Forward and backward linkage values are standardized to obtain the sensitivity index and dispersion index for use in the Klassen Typology analysis. Following Humavindu and Stage (2013):

$$FL_i = \frac{S_i}{\frac{1}{n}\sum_i S_i} \quad (5)$$

$$BL_j = \frac{r_j}{\frac{1}{n}\sum_j r_j} \quad (6)$$

FL_i: sensitivity index; BL_j: dispersion index; n: number of sectors; S_i: forward linkage coefficient; r_j: backward linkage coefficient.

The sensitivity and dispersion indices are plotted in the Klassen Typology quadrant. Sectors are classified into leading (Quadrant I), potential (Quadrants II and III), and regressive (Quadrant IV) categories. The classification follows the typology originally proposed by Klassen (1965) and later adapted for intersectoral linkage analysis by several scholars, including Fafurida (2012), Amin (2020), and Nugroho (2021), as shown in Table 1.

Table 1. Klassen typology

	Backward Linkages High (>1)	Low (<1)
Forward High (>1)	Leading Sector	Potential Sector
Forward Low (<1)	Potential Sector	Regressive Sector

Multiplier effect analysis

The multiplier effect analysis evaluates the impact of changes in endogenous variables on exogenous variables (final demand). It examines how changes in final demand affect value added and income in the i-th economic sector. Both income and value-added multipliers are derived from the Leontief inverse matrix $(I - A)^{-1}$, which captures both direct and indirect effects of changes in final demand. Based on the Leontief inverse matrix (UN, 1999), the income and value-added multipliers are:

$$MI = \sum_{i=1}^{n} \left(\frac{V_i}{X_i} \cdot \alpha_{ij}\right) \quad (7)$$

MI: income multiplier; V_i: wages/salaries in sector i; X_i: output of sector i; α_{ij}: Leontief inverse matrix.

$$V_j = \sum_{i=1}^{n} (V_{(n+1),i} \cdot \alpha_{ij}) \quad (8)$$

V_j: value-added multiplier; $V_{(n+1),i}$: ratio of value added to total output.

VECM analysis for inter-island spillover effects

To examine dynamic interactions and spillover transmission among islands, the Vector Error Correction Model (VECM) is employed to analyze whether the leading and highest-multiplier sectors generate spillover effects across the islands in NTT Province. The data comprise the accumulated GRDP of districts/cities in NTT Province for 2016–2023, grouped into three islands based on regional proximity, the availability of shipping routes for interaction, and an even distribution of regencies/cities. Taena et al. (2024) note that adjacent regencies/cities in NTT interact more intensively, forming economic agglomerations.

The VECM results provide insights into both short-term adjustments and long-term equilibrium among inter-island economies. This approach allows for the identification of short-term dynamics and long-term equilibrium relationships among regional economies. The grouping is shown in Table 2.

Table 2. Grouping of regencies/cities into three islands in NTT Province

No.	Islands	Regencies/Cities
1	Timor	Kupang City, Kupang Regency, TTS Regency, TTU Regency, Belu Regency, Malaka Regency, Rote Regency, Alor Regency
2	Flores	West Manggarai Regency, Manggarai Regency, East Manggarai Regency, Ngada Regency, Nagekeo Regency, Ende Regency, Sikka Regency, East Flores Regency, Lembata Regency
3	Sumba	Southwest Sumba Regency, West Sumba Regency, Central Sumba Regency, East Sumba Regency, Sabu Regency

VECM analysis begins with the Granger causality test to determine causality between regions (islands). A p-value smaller than the chosen significance level indicates causality between regions. The analysis then proceeds with VECM to assess spillover effects, referring to Gujarati (2024) and Ahmed & Jie (2019), modified as follows:

$$\Delta \log(\mathrm{GRDP}_{\mathrm{Timor}}) = \alpha_0 + \alpha_1 \Delta \log(\mathrm{GRDP}_{\mathrm{Flores}}) + \alpha_2 \Delta \log(\mathrm{GRDP}_{\mathrm{Sumba}}) + \mu_t \ldots\ldots (9)$$

$$\Delta \log(\mathrm{GRDP}_{\mathrm{Flores}}) = \alpha_0 + \alpha_1 \Delta \log(\mathrm{GRDP}_{\mathrm{Timor}}) + \alpha_2 \Delta \log(\mathrm{GRDP}_{\mathrm{Sumba}}) + \mu_t \ldots\ldots (10)$$

$$\Delta \log(\mathrm{GRDP}_{\mathrm{Sumba}}) = \alpha_0 + \alpha_1 \Delta \log(\mathrm{GRDP}_{\mathrm{Flores}}) + \alpha_2 \Delta \log(\mathrm{GRDP}_{\mathrm{Timor}}) + \mu_t \ldots\ldots (11)$$

RESULTS AND DISCUSSION

Forward linkage analysis

Forward linkage refers to the connection between an upstream production sector and its downstream sectors. It can be divided into two categories: direct forward linkage and direct and indirect forward linkage.

The value of the direct forward linkage indicates that if final demand increases by one unit, the output of a given sector will rise directly by the value of its linkage coefficient. Meanwhile, the direct and indirect forward linkage value represents the total impact (both direct and indirect) that an increase in output of one sector exerts on other sectors. As Widyawati (2017) explains, a higher forward linkage value indicates greater dependence of other sectors on that sector.

The direct forward linkage value is derived from the technical coefficient matrix, while the direct and indirect forward linkage values are obtained from the open Leontief inverse matrix. The results of the forward linkage analysis provide policymakers with a basis for prioritizing sectors to stimulate the growth of other economic sectors and

enhance the welfare of business actors (Hardiawan et al., 2019). The distribution of forward linkage values for each economic sector in NTT Province is presented in Table 3.

Table 3. Forward linkage in NTT Province

No	Sector	DFL	DIFL	Total
1	Agriculture, Forestry, and Fisheries	0.668	1.873	2.541
2	Mining and Quarrying	0.118	1.148	1.266
3	Manufacturing	0.260	1.330	1.590
4	Electricity and Gas Procurement	0.379	1.290	1.670
5	Water Supply, Rubbish and Waste Management, and Recycling	0.019	1.021	1.041
6	Construction	0.202	1.237	1.439
7	Wholesale and Retail Trade; Automobile and Motorcycle Repair	0.533	1.712	2.245
8	Transportation and warehousing	0.491	1.616	2.107
9	Provision of Accommodation and Food, and Beverages	0.099	1.111	1.210
10	Information and communication	0.426	1.593	2.019
11	Financial Services and Insurance	0.332	1.476	1.808
12	Real Estate	0.193	1.259	1.452
13	Corporate Services	0.111	1.155	1.265
14	Government Administration, Defense, and Compulsory Social Security	0.028	1.038	1.066
15	Educational Services	0.060	1.068	1.128
16	Health Services and Social Activities	0.078	1.087	1.164
17	Other Services	0.084	1.100	1.184
	Total	**4.379**	**23.214**	**27.593**

Notes: DFL=Direct Forward Linkage; DIFL= Direct and Indirect Forward Linkage

The results presented in Table 3 indicate that the agricultural sector has the highest direct forward linkage value (0.668). This means that if the total output of the agricultural sector increases by one unit, it will directly stimulate other sectors that use agricultural products as inputs by 0.668 units. Similarly, the agricultural sector shows the highest direct and indirect forward linkage value (1.873), indicating that a one-unit increase in the agricultural sector's output leads to an overall increase of 1.873 units in the regional economy.

The sectors with the highest total forward linkages are agriculture, trade, transportation, and information and communication. Growth in these sectors tends to stimulate development in other sectors within NTT Province. For example, agricultural expansion drives the growth of the processing, trade, transportation, and communication sectors. This finding aligns with Novalia (2024), who notes that sectors with strong economic linkages typically generate stronger economic multipliers.

Backward linkage analysis

Backward linkage refers to the relationship between downstream production sectors and their upstream sectors. It illustrates the extent to which a sector depends on inputs from other sectors to meet changes in final demand. Backward linkages are categorized into two types: direct backward linkages and direct and indirect backward linkages.

The backward linkage value indicates the amount of input a sector requires from other sectors (including its own sector) when final demand increases. According to Amin (2020), sectors with high backward linkages exhibit strong dispersion power, as their high input demand can drive regional economic growth.

The results presented in Table 4 show that the agricultural sector (4.379) and the manufacturing sector (4.288) have the highest direct backward linkage values. This indicates that when the output of the agricultural or manufacturing sector increases by one unit, it stimulates production in upstream sectors by approximately four units.

The analysis of direct and indirect backward linkages shows the highest value in the electricity and gas supply sector (2.132). This means that if the final demand for this

sector increases by one unit, it will generate an overall increase of 2.132 units in total economic activity. The sectors with the highest total backward linkages are electricity and gas supply, manufacturing, and agriculture.

Table 4. Backward linkage in NTT Province

No	Sector	DBL	DIBL	Total
1	Agriculture, Forestry, and Fisheries	4.379	1.187	5.565
2	Mining and Quarrying	3.476	1.250	4.727
3	Manufacturing	4.288	1.618	5.906
4	Electricity and Gas Procurement	3.787	2.132	5.919
5	Water Supply, Rubbish and Waste Management, and Recycling	3.220	1.402	4.622
6	Construction	2.939	1.343	4.282
7	Wholesale and Retail Trade; Automobile and Motorcycle Repair	2.685	1.306	3.991
8	Transportation and warehousing	2.451	1.311	3.762
9	Provision of Accommodation, Food, and Beverages	2.218	1.515	3.734
10	Information and communication	1.817	1.275	3.092
11	Financial Services and Insurance	1.608	1.139	2.747
12	Real Estate	1.503	1.156	2.659
13	Corporate Services	1.387	1.328	2.715
14	Government Administration, Defense, and Compulsory Social Security	1.140	1.340	2.480
15	Educational Services	0.899	1.248	2.147
16	Health Services and Social Activities	0.719	1.354	2.073
17	Other Services	0.466	1.309	1.775
	Total	**38.981**	**23.214**	**62.194**

Notes: DFL= Direct Backward Linkage; DIFL= Direct and Indirect Backward Linkage

Government and stakeholder support play a crucial role in strengthening the capacity of these sectors, particularly those that supply inputs to other sectors. This finding is consistent with Kustanto and Harnoto (2024), who emphasize the importance of government policies in supporting supplier sectors that underpin regional economic systems.

A high backward linkage value indicates that a sector relies heavily on inputs produced by other sectors within NTT Province. In contrast, a low value suggests greater dependence on inputs sourced from outside the province. The agricultural sector exhibits strong backward linkages as it increasingly uses locally produced inputs, such as organic fertilizers and pesticides sourced within NTT. Afandi et al. (2023) also highlight that agriculture typically demonstrates high linkage values due to its strong reliance on regional input networks. Similarly, manufacturing and construction show strong backward linkages, reflecting high interdependence with local input suppliers. These findings suggest that strengthening input-supplying industries can generate broader economic spillovers and enhance regional value chains in NTT.

Identification of leading sectors in NTT Province

Following the results of the linkage analysis, the subsequent discussion identifies the key sectors based on their combined forward and backward linkage strengths. Identifying leading sectors is essential for understanding the structural drivers of regional economic growth. In the context of Input–Output analysis, a leading sector exhibits strong linkages with other sectors, reflecting its ability to both stimulate and be stimulated by the rest of the economy. Such sectors play a strategic role in promoting intersectoral integration, generating multiplier effects, and accelerating overall regional development.

According to Muzdalifah et al. (2021), a sector with high forward and backward linkage values possesses a dual function: it drives growth in downstream industries through output distribution and, at the same time, strengthens upstream activities through intensive input utilization. The development of these sectors thus generates spillover benefits across both upstream and downstream value chains.

Following Fafurida (2012), the Klassen typology analysis was used to classify economic sectors based on their forward and backward linkage indices into four categories: leading, potential, less potential, and non-potential sectors. A sector with strong linkages indicates a high degree of local interdependence and limited reliance on external inputs or markets, demonstrating its capacity to sustain endogenous growth. The results of the leading sector identification for East Nusa Tenggara (NTT) Province are presented in Table 5.

Table 5. Classification of economic sectors based on forward and backward linkage analysis in NTT Province

No	Sektor	SFL	SBL	Classification
1	Agriculture, Forestry, and Fisheries	1.649	1.521	Leading Sector (Q1)
2	Mining and Quarrying	0.822	1.292	Potential Sector (Q3)
3	Manufacturing	1.032	1.614	Leading Sector (Q1)
4	Electricity and Gas Procurement	1.084	1.618	Leading Sector (Q1)
5	Water Supply, Rubbish and Waste Management, and Recycling	0.675	1.263	Potential Sector (Q3)
6	Construction	0.934	1.170	Potential Sector (Q3)
7	Wholesale and Retail Trade; Automobile and Motorcycle Repair	1.457	1.091	Leading Sector (QI)
8	Transportation and warehousing	1.367	1.028	Leading Sector (QI)
9	Provision of Accommodation, Food, and Beverages	0.785	1.021	Potential Sector (Q3)
10	Information and communication	1.310	0.845	Potential Sector (Q2)
11	Financial Services and Insurance	1.173	0.751	Potential Sector (Q2)
12	Real Estate	0.942	0.727	Non-Potential Sector (Q4)
13	Corporate Services	0.821	0.742	Non-Potential Sector (Q4)
14	Government Administration, Defense, and Compulsory Social Security	0.692	0.678	Non-Potential Sector (Q4)
15	Educational Services	0.732	0.587	Non-Potential Sector (Q4)
16	Health Services and Social Activities	0.756	0.567	Non-Potential Sector (Q4)
17	Other Services	0.768	0.485	Non-Potential Sector (Q4)

Notes: SFL=Standardized Forward Linkage; SBL= Standardized Backward Linkage

The results in Table 5 indicate that the leading sectors in NTT Province are agriculture, manufacturing, electricity and gas supply, trade, and transportation. These sectors exhibit strong linkages with other sectors in the province, underscoring their crucial role in driving intersectoral integration and regional economic growth.

Potential sectors are those that demonstrate moderate dependence on other sectors within NTT Province. These include the water supply, construction, information and communication, financial services, accommodation and food and beverage, and mining sectors. Both the leading and potential sectors contribute significantly to the province's economic development by using inputs from within the region and supplying outputs that serve as inputs for other local industries.

This finding is consistent with Rizani (2020) and Marconi et al. (2016), who emphasize that leading sectors should be prioritized in development planning to enhance economic growth and reduce poverty. The interconnectedness among economic sectors fosters a multiplier effect, where growth in one sector stimulates expansion in others. The dominance of agriculture and manufacturing as leading sectors reflects NTT's resource-based economic structure, indicating that regional development policies should focus on strengthening agro-industrial linkages and upgrading value chains to enhance inter-island economic integration.

Conversely, corporate services and real estate are classified as non-potential sectors, reflecting the limited presence of large-scale industries in NTT. This condition is partly due to the scarcity of continuously available raw materials. The real estate sector, in particular, remains underdeveloped because people in NTT tend to prefer larger landholdings for residential use that also support agricultural and livestock activities.

Multiplier effect analysis in NTT Province

The multiplier effect analysis examines how changes in final demand in one economic sector influence the performance of other sectors within the regional economy. An increase in final demand for a particular sector not only raises that sector's output but also stimulates additional production in other sectors, thereby expanding overall regional output. This chain reaction represents the essence of intersectoral interdependence in regional development.

The multipliers analyzed in this study consist of the income multiplier and the value-added multiplier, both of which are derived from the Leontief inverse matrix $(I - A)^{-1}$, capturing both direct and indirect effects of changes in final demand. According to Wang et al. (2024), multiplier effects arise from the synergistic integration among economic sectors, the expansion of household consumption, and technological innovation, all of which generate additional economic impacts.

Two types of multipliers are used in this study. Type I multipliers are obtained from the open Leontief inverse matrix, representing inter-industry effects, whereas Type II multipliers are derived from the closed Leontief inverse matrix, which incorporates the feedback effects of household consumption (Tariyal, 2016; Koylal et al., 2023).

- The Type I income and value-added multipliers indicate the increase in sectoral income and value added resulting from a one-unit rise in final demand.
- The Type II multipliers reflect the additional effects generated by higher household consumption induced by the initial demand increase, thereby amplifying total income and value added across all sectors.

The results of the multiplier effect analysis are presented in Table 6.

Table 6. Income and value-added multiplier coefficients of economic sectors in NTT Province

		Income		Value Added	
No	Sector	Multiplier-I	Multiplier-II	Multiplier-I	Multiplier-II
1	Agriculture, Forestry, and Fisheries	6.110	8.247	5.299	9.543
2	Mining and Quarrying	3.281	1.195	3.950	4.843
3	Manufacturing	5.033	1.314	5.197	6.385
4	Electricity and Gas Procurement	1.513	6.164	1.088	1.317
5	Water Supply, Rubbish and Waste Management, and Recycling	1.856	2.024	1.051	1.233
6	Construction	5.761	1.217	1.110	1.320
7	Wholesale and Retail Trade; Automobile and Motorcycle Repair	1.088	1.131	1.138	1.212
8	Transportation and warehousing	3.301	1.252	1.114	1.446
9	Provision of Accommodation, Food, and Beverages	3.096	1.854	1.105	1.357
10	Information and communication	5.445	1.282	1.447	1.819
11	Financial Services and Insurance	4.126	1.180	1.076	1.407
12	Real Estate	5.876	1.191	1.158	1.724
13	Corporate Services	1.925	4.301	2.333	3.240
14	Government Administration, Defense, and Compulsory Social Security	1.095	1.172	1.033	1.398
15	Educational Services	5.126	1.161	1.159	1.431
16	Health Services and Social Activities	3.290	1.840	1.478	1.906
17	Other Services	3.731	1.435	1.143	1.392
	Total	61.653	37.960	32.879	43.973

The results indicate that the agricultural sector provides the highest income multiplier effect (both Type I and Type II) among all sectors. The Type II income multiplier value for agriculture is 8.247, meaning that a one-million-rupiah increase in final demand in this sector raises the total regional income by approximately eight million rupiah. Armelly et al. (2022) emphasize that agriculture functions as a major contributor

to regional economies and exerts substantial spillover effects on other sectors, including manufacturing.

The analysis also found that in several sectors, such as construction and manufacturing, the Type I income multiplier exceeds the Type II multiplier. The condition suggests that inter-industry linkages generate stronger multiplier effects than household consumption feedback.

The highest value-added multiplier is also observed in agriculture (9.543), followed by manufacturing (6.385). This implies that a one-million-rupiah increase in agricultural final demand raises the province's total added value by around 9.5 million rupiah. In comparison, the same increase in manufacturing demand generates an additional 6 million rupiah in value added.

These findings are consistent with Rafiqah (2020), who asserts that the agricultural sector generates the largest income multiplier and serves as a key foundation for regional development policy. Likewise, Kim (2024), drawing on Jacobsen's framework, highlights that multiplier analyses provide policymakers with critical empirical inputs for designing sectoral and regional development strategies.

Impact of the leading sector and multiplier on the spillover effect of islands in NTT Province

The interrelationship between economic sectors extends beyond regional boundaries, encompassing linkages within and across sectors in different regions. According to Muchdiea et al. (2020), interactions between regions occur through the exchange of goods and services—commonly known as the spillover effect—which refers to the economic impact on one region from another region's economic activities. Variations in economic potential among regions form the foundation for such interregional interactions.

In NTT Province, the agricultural and manufacturing sectors are the leading sectors and exhibit the highest multipliers. In other words, these two sectors represent the intersection between the leading and high-multiplier categories, positioning them as key drivers of inter-island spillover effects. Both sectors play a crucial role in enhancing economic growth across the province's islands. Agazu and Kero (2024) and Hassan et al. (2023) assert that innovation, competitiveness, and investment in productive sectors have a positive causal relationship with economic growth.

To examine whether the leading sectors of each island influence the economies of other islands, a Vector Error Correction Model (VECM) analysis was conducted. The VECM model testing involved four main stages: stationarity testing, optimal lag determination, cointegration analysis, and Granger causality testing. These tests were conducted to evaluate data stationarity and the causal relationships among the islands in NTT Province, providing the foundation for VECM estimation.

Stationarity testing employed the Augmented Dickey–Fuller (ADF) method (Njoroge, 2023). The results indicate that the GRDP variable for each island is non-stationary at the level, but becomes stationary after first differencing. The results are shown in Table 7.

Table 7. ADF unit root test results for GRDP of NTT islands

Variable	Unit Root	Stat. ADP	Probability
GRDP of TIMOR Island	Level	14.632	0.546
	1st difference	74.526	0.001
GRDP of FLORES Island	Level	10.523	0.234
	1st difference	86.245	0.000
GRDP of FLORES Island	Level	5.6235	0.025
	1st difference	78.427	0.000

After establishing data stationarity, the optimal lag length was determined to identify the appropriate number of lags representing the influence of past variables. The Akaike Information Criterion (AIC) was used for this purpose (Gao & Wang, 2025). The results, shown in Table 8, indicate that the optimal lag is two, as reflected by the smallest AIC value.

Table 8. Lag length selection criteria for GRDP variables

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1254.52	264.2983	7.7532	40.8424	67.634	41.6352
1	-2823.52	3.6354	78.5312*	39.3421*	36.624*	39.095*
2	-5243.45	7.3528	6.5429	40.7534	64.639	40.213
3	-3829.42	4.5372	7.5308	41.8532	92.7345	40.742
4	-2652.53	3.6234	6.4192	42.3297	78.462	40.892

Cointegration testing was performed using the Johansen test (Njoroge, 2023; Risma et al., 2024) to identify long-term relationships among GRDP variables across islands. The test produced p-values smaller than $\alpha = 0.05$, indicating cointegration among the GRDP variables and thereby justifying the use of the VECM model. The results are presented in Table 9.

Table 9. Johansen cointegration test for GRDP variables

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	Critical Value (5%)	Prob.** Critical Value
None *	0.93427	300.6453	16.5354	0.000
At Most 1*	0.32632	56.6342	4.6352	0.000
At Most 2*	0.43742	52.3712	5.6243	0.000
At Most 3*	0.42323	51.6342	5.0143	0.000

The results of the Granger causality test (Table 10) indicate significant causality ($\alpha = 0.01$) among the three major islands in NTT Province, suggesting economic integration across the islands through the agricultural and manufacturing sectors. Differences in agricultural potential among the regencies of Timor, Flores, and Sumba explain these causal relationships. According to Sari (2022), two-way causality between regions—whether positive or negative—can be further analyzed through VECM estimation.

Table 10. Granger causality test for inter-island GRDP relationships

Null Hypothesis:	Obs	F-Statistic	Prob.
SUMBA01 does not Granger-cause FLORES01	38	20.6349	1.E-08**
FLORES01 does not Granger-cause SUMBA01		116.204	1.E-14**
TIMOR01 does not Granger-cause FLORES01	38	10.1943	1.E-05**
FLORES01 does not Granger-cause TIMOR01		10.3983	1.E-03**
TIMOR01 does not Granger-cause SUMBA01	38	9.27327	0.000**
SUMBA01 does not Granger-cause TIMOR01		10.69573	1.E-06**

The interactions among islands indicate that the spread effect occurs between Sumba and Timor, and between Timor and Flores, while the backwash effect is more pronounced between Timor and Flores in both directions. These results imply that improving inter-island logistics and strengthening trade networks are crucial for enhancing equitable regional growth across NTT Province.

These findings resonate with recent regional development studies emphasizing the role of inter-island connectivity and sectoral specialization in sustaining inclusive growth (Balland & Boschma, 2021; Das et al., 2022). This broader perspective highlights that enhancing spatial linkages among island economies not only fosters balanced growth

within provinces such as NTT but also contributes to the resilience of archipelagic regional systems.

Yuliawan et al. (2022) note that regional economic integration enhances the spillover effects of commodities, thereby stimulating growth both within and beyond the originating regions. Similarly, Huo and Ahmed (2017) argue that interregional connections improve overall economic efficiency. The results of the VECM analysis are summarized in Table 11.

Table 11. VECM estimation results for GRDP of NTT islands

	FLORES	SUMBA	TIMOR
D(FLORES(-1),2)	-0.660740	-0.066019	-0.029514
	(0.16784)	(0.07183)	(0.06801)
	[-3.93674]*	**[-2.91904]***	**[-2.43394]***
D(FLORES(-2),2)	-0.332255	-0.038973	-0.016555
	(0.16578)	(0.07095)	(0.06718)
	[-2.00424]*	**[-3.54929]***	**[-4.24644]***
D(SUMBA(-1),2)	0.048308	0.346615	0.484898
	(0.61336)	(0.26252)	(0.24855)
	[2.07876]*	[2.32036]*	**[2.95092]***
D(SUMBA(-2),2)	0.022546	0.148309	0.230899
	(0.42567)	(0.18218)	(0.17249)
	[2.05297]*	[2.81406]*	**[2.33862]***
D(TIMOR(-1),2)	-0.018441	0.067922	-0.650824
	(0.44135)	(0.18890)	(0.17885)
	[-6.04178]*	**[4.35957]***	**[-3.63899]***
D(TIMOR(-2),2)	-0.013046	0.025498	-0.341729
	(0.44017)	(0.18839)	(0.17837)
	[-3.02964]*	**[4.13535]***	**[-2.91589]***

The results in Table 11 indicate significant short-run interactions among the three islands. Figure 2 further shows the impulse response functions, which illustrate the dynamic direction and magnitude of these effects.

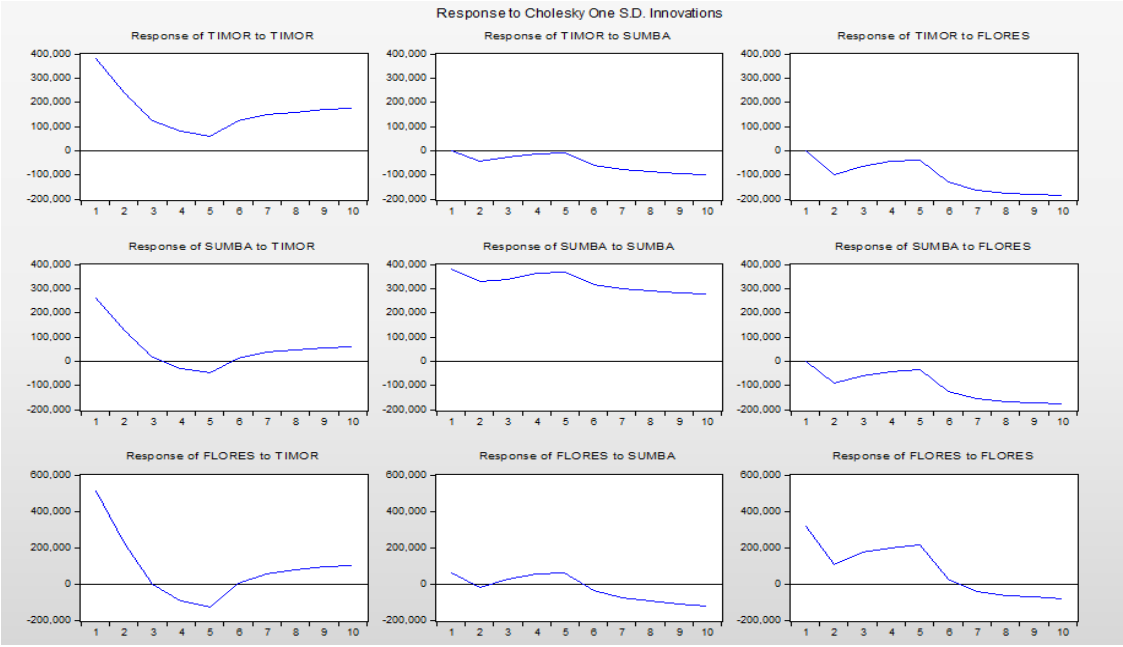

Figure 2. Impulse response functions

The VECM results reveal the presence of both spread effects and backwash effects among the islands of NTT Province. The interaction between Flores and Sumba, and between Flores and Timor, produces a backwash effect, indicating that Flores benefits more from these inter-island interactions, particularly in the agricultural and manufacturing sectors. This advantage is attributed to Flores's greater openness to information, which facilitates faster technological adoption and agricultural innovation. As Xu et al. (2005) explain, regional economic growth is influenced by technological advancement, service industry development, population, and openness levels.

The long-term GRDP relationship between Flores and Timor shows fluctuations, declining to negative values in the fourth and fifth years. The negative trend lasts only two years, then recovers in the sixth year and continues to increase until the tenth year.

In contrast, interactions from Timor to Sumba exhibit a spread effect. At the same time, those from Timor to Flores indicate a backwash effect, suggesting that mutual interactions between Timor and Flores are competitively substitutive rather than complementary. Delgado-Viñas and Gómez-Moreno (2022) similarly note that such interactions can be mutually disadvantageous when regions adopt overlapping economic functions. The long-term GRDP relationship between Timor, Sumba, and Flores remains negative.

A different pattern emerges for Sumba, which exerts a spread effect on both Flores and Timor. Economic changes in Sumba have a positive spillover effect, influencing commodity prices and NTT Province's overall GRDP. Abdel-Latif and Popescu (2025) argue that regional economic shocks affect GDP, inflation, and commodity prices, thus requiring well-structured interregional networks. This is consistent with Balland and Boschma (2021), who emphasize the importance of network complementarities for regional resilience.

The GRDP relationship between Sumba and Timor shows a decline until the fifth year, followed by a recovery. A different relationship exists between Sumba and Flores, which remains negative over the long term.

Therefore, stronger synergistic inter-island cooperation is needed to reduce economic disparities across NTT Province. This can be achieved by increasing product value-added, promoting small and medium-sized enterprises (SMEs), expanding access to capital, developing transportation infrastructure, and strengthening business networks. These findings are consistent with Soebagyo and Hascaryo (2016) and Rizani (2020), who highlight that infrastructure development, technological enhancement, and investment growth are essential for achieving balanced regional economic development.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study concludes that the leading sectors in East Nusa Tenggara (NTT) Province are agriculture, manufacturing, electricity, trade, and transportation, as these sectors exhibit the strongest forward and backward linkages within the regional economy. The agricultural and manufacturing sectors also generate the highest economic multipliers, serving as both leading sectors and the primary drivers of intersectoral integration.

The analysis further reveals that these two sectors produce significant spillover effects across the province's major islands. A spread effect is observed in the interactions between Sumba and Timor, Sumba and Flores, and Timor and Sumba. In contrast, a backwash effect occurs bidirectionally between Timor and Flores and between Flores and Sumba. These findings confirm the structural interdependence among NTT's island

economies and underscore the crucial role of productive sector linkages in fostering inclusive regional growth.

By integrating intersectoral linkage, multiplier, and spillover analyses, this study contributes empirically to understanding how sectoral strengths translate into spatial economic diffusion within multi-island regions. Conceptually, the findings extend the application of *regional growth and spillover theory* to archipelagic economies, offering a deeper perspective on the spatial dynamics of regional interdependence.

Recommendations

To enhance the positive spillover effects and promote balanced inter-island growth, it is essential to strengthen production capacity in the agricultural and manufacturing sectors. This can be achieved through the promotion of small and medium enterprises (SMEs), improved access to capital and business networks, and the development of transportation and logistics infrastructure that supports efficient inter-island trade. Strengthening agro-industrial linkages and value-chain upgrading will also help increase local value added and ensure that economic benefits are distributed more equitably across islands.

Future studies are encouraged to examine the frequency and composition of inter-island trade flows, the types of commodities exchanged, and the factors that influence economic integration in NTT Province. Extending the temporal and sectoral scope of analysis will enrich the empirical foundation for designing more adaptive and inclusive regional development policies.

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AUTHOR CONTRIBUTIONS

Conceptualization: Werenfridus Taena.
Methodology: Anggelina Delviana Klau, Fried Markus Alung Blegur, Febrya Christin Putri Handayani Buan.
Software and Formal Analysis: Anggelina Delviana Klau, Febrya Christin Putri Handayani Buan.
Data Curation, Project Administration: Marce Sherly Kase, Felisisima Afoan.
Visualization: Fried Markus Alung Blegur.
Writing – Original Draft: Werenfridus Taena, Anggelina Delviana Klau, Marce Sherly Kase, Fried Markus Alung Blegur, Felisisima Afoan, Febrya Christin Putri Handayani Buan.
Writing – Review & Editing: Werenfridus Taena.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCE

Abdel-Latif, H., & Popescu, A. (2025). *Spillovers from large emerging economies: How dominant is China?* International Monetary Fund.

Afandi, A. T., Kurniyawan, E. H., Nabilah, P., Wanda, I. P., Mauliya, F. R. A., Kurniawan, D. E., & Nur, K. R. M. (2023). Overview leptospirosis in agricultural: Literature review. *Health and Technology Journal (HTechJ)*, *1*(5), 547–557.

Agazu, B. G., & Kero, C. A. (2024). Innovation strategy and firm competitiveness: A systematic literature review. *Journal of Innovation and Entrepreneurship*, *13*(1). https://doi.org/10.1186/s13731-024-00381-9

Ahmed, N. M., & Jie, L. (2019). A vector error correction model (VECM) approach in explaining the impact of livestock export on economic growth in Somalia. *IOSR Journal of Economics and Finance (IOSR-JEF)*, *10*(1), 32–39.

Amir, H., & Nazara, S. (2005). Analisis perubahan struktur ekonomi (economic landscape) dan kebijakan strategi pembangunan Jawa Timur tahun 1994 dan 2000: Analisis input-output. *Jurnal Ekonomi dan Pembangunan Indonesia*, *5*(2), 37–55.

Ashfaq, S., Tang, Y., & Maqbool, R. (2020). Dynamics of spillover network among oil and leading Asian oil trading countries' stock markets. *Energy*, *207*, 118077. https://doi.org/10.1016/j.energy.2020.118077

Balland, P. A., & Boschma, R. (2021). Complementary interregional linkages and smart specialization: An empirical study on European regions. *Regional Studies*, *55*(6), 1059–1070. https://doi.org/10.1080/00343404.2020.1861240

Baransano, M. A., Intan, E., Putri, K., Achsani, N. A., & Kolopaking, L. M. (2016). Analysis of factors affecting regional development disparity in the Province of West Papua. *Journal of Economics and Development Studies*, *4*(2), 115–128. https://doi.org/10.15640/jeds.v4n2a10

Cahyono, B., & Sumargo, B. (2005). Mengartikulasikan tabel input-output dan kerangka analisisnya. *He Winners*, *6*(1), 33–50.

Ciaffi, G., Deleidi, M., & Di Domenico, L. (2024). Fiscal policy and public debt: Government investment is most effective to promote sustainability. *Journal of Policy Modeling*, *46*(6), 1186–1209. https://doi.org/10.1016/j.jpolmod.2024.07.002

Das, S., Magistretti, G., Pugacheva, E., & Wingender, P. (2022). Sectoral spillovers across space and time. *Journal of Macroeconomics, 72,* 103422. https://doi.org/10.1016/j.jmacro.2022.103422

Delgado-Viñas, C., & Gómez-Moreno, M. L. (2022). The interaction between urban and rural areas: An updated paradigmatic, methodological and bibliographic review. *Land, 11*(8), 1–21. https://doi.org/10.3390/land11081298

Fafurida, & Nihayah, D. M. (2012). Pengembangan unit usaha industri kecil melalui metode pemetaan dan need assessment. *Jejak, 5*(1), 1–10.

Gao, L. & Wang, Y. (2025). *Understanding Price–Volume Relationships and Volume Determinants in China's Carbon Trading System*. Available at SSRN: http://dx.doi.org/10.2139/ssrn.5351318

Gujarati, D. N. (2024). *Basic econometrics* (4th ed.). McGraw-Hill Education.

Hardiawan, D., Yusuf, A. A., & Muljarijadi, B. (2019). The impact of expenditure inequality and socioeconomic factors on crime rates in Indonesia: A cross-sectional study using spatial econometrics and geographically weighted regression. In *Achieving and Sustaining SDGs 2018 Conference: Harnessing the Power of Frontier Technology to Achieve the Sustainable Development Goals (ASSDG 2018)* (pp. 150–169).

Hartono, D., Priyarsono, D. S., Nguyen, T. D., & Ezaki, M. (2007). Regional economic integration and its impacts on growth, poverty, and income distribution: The case of Indonesia. *Review of Urban and Regional Development Studies, 19*(2), 138–153.

Hirschman, A. O. (1958). *The strategy of economic development.* Yale University Press.

Humavindu, M. N., & Stage, J. (2013). Key sectors of the Namibian economy. *Journal of Economic Structures, 2*(1), 1–15.

Huo, R., & Ahmed, A. D. (2017). Return and volatility spillover effects: Evaluating the impact of Shanghai–Hong Kong Stock Connect. *Economic Modelling, 61,* 260–272. https://doi.org/10.1016/j.econmod.2016.09.021

Husin, I., Muzdalifah, M., & Aziz, Y. (2021). Analisis pemasaran sapi potong di Kecamatan Takisung Kabupaten Tanah Laut. *Frontier Agribisnis, 5*(3).

Izuchukwu, O. (2015). Analysis of the contribution of the agricultural sector to the Nigerian economic development. *World Review of Business Research, 1*(1), 191–200.

Jannah, L. T. W., & Tasriah, E. (2022). Analisis input-output: Peranan industri terkait pariwisata di Provinsi Sumatera Barat. *Jurnal Ekonomi Pembangunan, 11*(1), 11–21. https://doi.org/10.23960/jep.v11i1.390

Kilateng, F., Sondakh, M. L., & Abstract, C. B. D. P. (2017). Analisis multiplier effect agribisnis tomat terhadap perekonomian di Desa Tonsewer Selatan Kecamatan Tompaso Barat. *Agri-SosioEkonomi, 13*(1), 195–202.

Kim, K. (2024). An input–output analysis for the economic potential of a new convergence industry: A focus on the autonomous vehicle sector in South Korea. *Sustainability (Switzerland), 16*(20), 8816. https://doi.org/10.3390/su16208816

Koylal, J. A., Kuang, S. M., & Abineno, J. C. (2023). Penentuan sektor industri pengolahan unggulan dalam perekonomian Nusa Tenggara Timur. *Seminar Nasional Politani Kupang, 7*(12), 358–367.

Koylal, J. A., Kuang, S. M., & Abineno, J. C. (2023). Dampak pengganda sektor industri pengolahan unggulan terhadap perekonomian Nusa Tenggara Timur. *Media Ekonomi, 31*(2), 165–180. https://doi.org/10.25105/me.v31i2.18435

Kustanto, G., & Harnoto, L. B. (2024). Analysis of structure, conduct, and performance of agro-industry in the Daerah Istimewa Yogyakarta (DIY) in 2016 using the input–output approach. *Proceedings, 487*, 1–8.

Logaritma, S. W. M. (2022). Keterkaitan ekonomi Gorontalo dalam perspektif tabel IO dan IRIO tahun 2016. *Gorontalo Development Review, 5*(1), 1–15.

Marconi, N., de Borja Reis, C. F., & de Araujo, E. C. (2016). Manufacturing and economic development: The actuality of Kaldor's first and second laws. *Structural Change and Economic Dynamics, 37*, 75–89. https://doi.org/10.1016/j.strueco.2016.01.004

Mardalena, M., Adji, A., Suhel, S., Andaiyani, S., & Harunurrasyid, H. (2019). How leading economic sectors stimulate economic growth, income, and labor absorption? An input–output approach. *International Journal of Economics and Financial Issues, 9*(1), 234–244. http://www.econjournals.com

Mourao, P. R., & Popescu, I. A. (2022). Revisiting a macroeconomic controversy: The case of the multiplier–accelerator effect. *Economies, 10*(10), 249. https://doi.org/10.3390/economies10100249

Muchdie, M., Imansyah, M. H., & Prihawantoro, S. (2020). Keterkaitan spasial di enam negara Asia: Analisis input–output dunia. *Jurnal Ekonomi dan Pembangunan Indonesia, 20*(1), 20–32.

Njoroge, F. (2023). *Effect of tax revenue growth on economic growth in Kenya* [Master's thesis, University of Nairobi].

Novalia, W., Farrelly, M., & Raven, R. (2024). Place-based and sectoral patterns in urban experimentation: Implications for deep transitions research. *Environmental*

Innovation and Societal Transitions, 53, 100922. https://doi.org/10.1016/j.eist.2024.100922

Nugroho, Y. D. (2021). Analysis of input–output table: Identifying leading sectors in Indonesia (case study in 2010, 2016, and 2020). *Proceedings of the International Conference on Data Science and Official Statistics, 1*(1), 985–997. https://doi.org/10.34123/icdsos.v2021i1.251

Paramita, P. F. C., Amin, C., & Setiawan, S. M. (2020). Evaluasi penentuan pusat-pusat pertumbuhan dalam pengembangan wilayah di Kabupaten Wonogiri [Doctoral dissertation, Universitas Muhammadiyah Surakarta].

Puspita, C., & Ningsih, W. (2021). Implementasi Inter-Regional Input-Output (IRIO) dalam Pemulihan Perekonomian Wilayah akibat Pandemi Covid-19 di Indonesia. *Seminar Nasional Official Statistics*, *2021*(1), 313-321. https://doi.org/10.34123/semnasoffstat.v2021i1.862.

Qibti, M. H. M., & Hendarto, R. M. (2020). Analisis spillover effect pertumbuhan ekonomi antar kabupaten/kota di kawasan Purwomanggung Jawa Tengah tahun 1988–2018. *Diponegoro Journal of Economics, 9*(4), 1–12.

Rafiqah, I. (2020). Analisis multiplier sektor pertanian pada perekonomian Provinsi Jawa Tengah, Indonesia. *Jurnal Ilmu-Ilmu Pertanian Agrisia, 3*(1), 14–31.

Rambe, R. A., Purmini, P., Armelly, A., Alfansi, L., & Febriani, R. E. (2022). Efficiency comparison of pro-growth poverty reduction spending before and during the COVID-19 pandemic: A study of regional governments in Indonesia. *Economies, 10*(6), 150. https://doi.org/10.3390/economies10060150

Rasmussen, P. N. (1957). *Studies in inter-sectoral relations.* Amsterdam: North-Holland Publishing Company.

Risma, O. R., Sari, Y. P., & Juliansyah, R. (2024). Hubungan ekspor, kurs, dan produk domestik bruto: Vector error correction model (VECM) approach. *Innovative: Journal of Social Science Research, 4*(1), 12135–12143.

Rizani, A. T., & Oktafien, S. (2020). The influence of organizational culture and work discipline on employee performance of PT. BFI Finance Indonesia Tbk. *Technium Social Sciences Journal, 1*(4), 483–492.

Rizani, M., Widyanti, R., Kurniaty, K., Shaddiq, S., & Yahya, M. Y. D. (2020). Effect of toxic leadership on organizational performance with workplace deviant behavior of employees as mediation. *Strategic Management Business Journal, 2*(1), 26–38.

Sari, J. P. (2022). *Aplikasi vector error correction model (VECM) untuk analisis jumlah uang beredar luas dan nilai tukar terhadap inflasi di Indonesia tahun 2003–2021* [Undergraduate thesis, Universitas Lampung].

Soebagyo, D., & Hascaryo, A. S. (2016). Leading sectors in 15 districts in Central Java. *Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi dan Pembangunan, 17*(1), 74–83.

Suripto, S & Lestari, D.E. (2019). Pengaruh pembangunan infrastruktur terhadap PDRB di provinsi Indonesia. *Wahana, 21*(1), 15–27.

Taena, W., Klau, A. D., Kase, M. S., Markus, F., & Blegur, A. (2024). Optimizing horticultural commodity-based spatial interactions in West Timor, Indonesia. *International Journal of Sustainable Development and Planning, 19*(2), 767–774.

Tariyal, P. (2016). Industry-specific multipliers to identify key industries of the Indian economy: An application of input–output analysis. *Global Journal of Human-Social Science: Economics, 16*(4), 1–12.

United Nations (UN). (1999). *Handbook of input–output table compilation and analysis.* Department of Economic and Social Affairs, Statistics Division.

Wang, F., Wang, H., & Xiong, L. (2024). Does the digital economy exhibit multiplier effects? A case study on the optimization of agricultural production structure in rural digital economy. *International Journal of Agricultural Sustainability, 22*(1), 1–21. https://doi.org/10.1080/14735903.2024.2386821

Widyawati, R. (2017). Analisis keterkaitan sektor pertanian dan pengaruhnya terhadap perekonomian Indonesia (analisis input–output). *Jurnal Economia, 13*(1), 14–27.

Xu, J., Li, G., Wang, P., Velazquez, H., Yao, X., Li, Y., Wu, Y., Peixoto, A., Crowley, S., & Desir, G. V. (2005). Renalase is a novel, soluble monoamine oxidase that regulates cardiac function and blood pressure. *Journal of Clinical Investigation, 115*(5), 1275–1280. https://doi.org/10.1172/JCI24066

Yuliawan, D., Hakim, D., Juanda, B., & Fauzi, A. (2022). Classification and prediction of rural socio-economic vulnerability (IRSV) integrated with social–ecological system (SES). *Decision Science Letters, 11*(3), 223–234.

Zamani, Z., & Tayebi, S. K. (2021). Spillover effects of trade and foreign direct investment on economic growth: An implication for sustainable development. *Environment, Development and Sustainability, 24*(9), 3967–3981. https://doi.org/10.1007/s10668-021-01546-5

Zhong, Y. D., & Leonard, N. (2020). Unsupervised learning of Lagrangian dynamics from images for prediction and control. *Advances in Neural Information Processing Systems, 33*(3), 10741–10752.