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Leveraging Input-Output Technology to Identify Key Economic Clusters of the Jizan Region

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Abstract:

This study ascertains the primary sectors of the Jizan region by analyzing interindustry connections. The study employs input-output tables and input-output modelling to perform a linkage analysis, which evaluates the forward and backward connections between sectors. The findings highlight that the main sectors exhibiting strong interdependencies with other sectors are 'manufacturing,' 'agriculture,' 'information & communication,' and 'wholesale & retail trade. This study emphasizes the role of input-output technology within these sectors, particularly in enhancing productivity, streamlining processes, and fostering innovation. The capacity of these sectors to drive production, create jobs, and facilitate economic development through robust industry connections renders them critical.

Keywords: *Input-output technology, forward linkages, backward linkages, key sectors.*

I. INTRODUCTION

The production sectors are interdependent, either as suppliers fulfilling the demands of other sectors (forward linkage) or as catalysts for increased production for some sectors (backward linkage) [1][7]. Understanding interindustry connections is crucial because investors, the business community, and governments favor sectors with solid industry ties over weak ones. Intense direct and indirect ties to various sectors are preferred since the greater amplitude of the cyclical swings of sectors is a function of the strongly correlated sectors because fluctuations in the demand for commodities induce fluctuations in the demand for the goods that go into them, making them exaggerated and, therefore, quickening the production cycle. Similarly, compared to sectors with weak or poor industry relations, those with strong ties will probably produce more and create more jobs per unit of end demand [3]. Moreover, the income distribution is often skewed in the enclave sectors. It occurs in emerging nations when the primary purpose of these technologically and geographically separated companies is to manufacture goods for export or the local populace that is associated with the enclave enterprises [4]. Large-scale interindustry links suggest substantial information flows between the various economic sectors.

An extensive body of scholarship has examined the interconnectedness among various sectors, considering the variety of geographical settings from socioeconomic and institutional perspectives. This study conducts interindustry linkages in the Jizan region to determine the main sectors of the Jizan economy. The next section depicts the research methodology, followed by the results in Section 3. Discussion and conclusion are illustrated in Section 4, while sections 5 and 6 present the theoretical and practical contributions.

II. METHODOLOGIES AND TECHNIQUES

A. Data:

This study utilizes the table of input-output (IO) transactions of the Jizan region for 2020, which captures the economic transactions between industries within the region for that year. It provides essential details on how products flow from each sector acting as a producer to various sectors acting as consumers [4]. This basic data to calibrate an IO model is

detailed in the inter-industry transaction table whose rows illustrate how a sector's output is distributed across the country, and the columns depict each sector's requirement of inputs for manufacturing its products [6].

		PRODUCERS AS CONSUMERS								FINAL DEMAND			
		Agric.	Mining	Const.	Manuf.	Trade	Transp.	Services	Other	Personal Consumption Expenditures	Gross Private Domestic Investment	Govt. Purchases of Goods & Services	Net Exports of Goods & Services
PRODUCERS	Agriculture												
	Mining												
	Construction												
	Manufacturing												
	Trade												
	Transportation												
	Services												
	Other Industry												
VALUE ADDED	Employees	Employee compensation								GROSS DOMESTIC PRODUCT			
	Business Owners and Capital	Profit-type income and capital consumption allowances											
	Government	Indirect business taxes											

Figure 1. Framework of input-output table

Source: [8]

The shaded portion in Figure 1 represents these interindustry exchanges. The Final Demand portion presents the sales columns of each sector's output to end users, comprising private consumers, government, and exports. For instance, electricity is sold both as input to other sectors (an intermediate transaction) and directly to end users (a final-demand sale). Furthermore, the Value Added presented by rows captures inputs to production, including labor, capital, taxes, and imports [7]. IOTs are widely used to study economic interactions across sectors and industries because they show detailed connections between institutions, industries, and sectors [2][13][11].

B. The Input-Output Technology:

The IO model, developed by Leontief, gives an analytical tool for analyzing inter-industry connections within an economy. In the basic Leontief model, industry j manufactures its products, denoted by output xj, using intermediate inputs, denoted by zij, provided by industry i. The output exhibits a linear relationship with intermediate inputs, which is captured by the matrix a_{ij} of the technical coefficients [12], defined as:

$$a_{ij} = {}^{z_{ij}}/_{x_j} \qquad (1)$$

This implies:

$$z_{ij} = (a_{ij})x_j; \quad 0 \le a_{ij} \le 1 \qquad (2)$$

The vector of intermediate inputs with n sectors is denoted as Ax. Here, x represents the (n x 1) vector of the industry's output, and C forms the (n x n) matrix containing input coefficients. Formally, we can write it mathematically as*:*

$$\mathrm{x} = \mathrm{Cx} + \mathrm{f} \qquad (3)$$

Here, f represents the final demand vector of the institutional sectors. A precise Leontief model is obtained by rearranging equation (3).

$$\mathrm{x} = (\mathrm{I} - \mathrm{C})^{-1}\mathrm{f} = \mathrm{Lf} \qquad (4)$$

Let $(I - C)^{-1}$ be referred to as the Leontief inverse and represented by L. It is alternatively referred to as a multiplier matrix or structural matrix where each element l_{ij} represents the incremental industry *I's* output resulting from a unit change in the final demand for the production of industry *j*.

C. Linkage Analysis:

The IO model gives us a structural matrix L for the linkage analysis. In IO technology, the sector's production presents two distinct impacts on other economic sectors, as purchaser and as seller. Increasing the sector j's output raises its demands as a purchaser of the sectors whose inputs are utilized for production. The term "backward linkage" denotes

this type of interlink between a specific sector and the sectors that provide inputs, as this is the cause in the conventional demand-side IO model [5]. Conversely, an increase in the sector j's output also implies that a greater quantity of j's product is available for use as inputs for the production of other sectors. In other words, there is an increase in product supply from sector j as a seller to the sectors that rely on it for their production. This is the cause direction in the supply-side IO model. This type of interlink between a specific sector and the other sectors where it sells its output is called forward linkage. Measures have been suggested to quantify the economic "connectedness" or backwards and forward linkages. One method to determine "key" or "leading" sectors in a single economy and for grouping sectors into spatial clusters is to compare the strengths of backward and forward linkages. The evolution of these interconnections can be examined if data is available for more than one time period. Additionally, conducting international comparisons and reviewing these measures in similar sectors in various countries provides the production structure.

Based on the higher degree of backward linkage between sector i and sector j, it can be deduced that a one-dollar increase in the sector i's output would have a more favorable effect on the economy compared to an equivalent rise in the sector j's output in terms of the total productive activity generated by the sector. In a similar vein, if the forward linkage of sector r exceeds that of sector s, it can be argued that a dollar increase in the output of sector r is more crucial for the economy than a corresponding increase in the production of sector s, considering the total productive activity it can sustain.

The linkage analysis, also called dispersion analysis, refers to the examination of production structures using two specific indices: the power of dispersion index and the sensitivity dispersion index [9][10](. The dispersion index quantitatively measures the extent of backward links between the sectors of the economy. Conversely, the sensitivity dispersion index illustrates the direct connections between different economic sectors. The strength of the linkage index can be categorized into three distinct levels. An index value of 1 indicates a strong linkage, which denotes a flawless connection or interaction. Intermediate linkage falls between 1 and 0.9, where the connection is still robust but not absolute. Finally, a weak linkage is defined when the index value is less than 0.9, signalling a diminishing or less significant interaction.

Mathematically, the power of the dispersion index, $\pi_{.j}$, is defined as follows:

$$\pi_{.j} = \frac{\frac{1}{M}.r_{.j}}{\frac{1}{M^2}.\sum_{j=1}^{M} r_{.j}} \qquad (5)$$

Where $r_{.j}$ is the j^{th} industry backward linkage, $\sum_{j=1}^{M} r_{.j}$ is the sum of all backward linkages, and M is the total number of industries. Similarly, the index of sensitivity dispersion, $\tau_{i.}$, is defined as:

$$\tau_{i.} = \frac{\frac{1}{M}.r_{i.}}{\frac{1}{M^2}.\sum_{i=1}^{M} r_{i.}} \qquad (6)$$

Where $r_{i.}$ is the i^{th} industry forward linkage, $\sum_{i=1}^{M} r_{i.}$ is the sum of all forward linkages, and M is the total number of commodities.

III. FINDINGS

Figure 2 indicates that 'agriculture,' 'mining & quarrying,' 'manufacturing,' 'Wholesale & retail trade,' 'Repair of motor vehicles & motorcycles,' and 'Information and communication,' exhibit strong forward linkages with index values one or more than one. On the other hand, the sectors with strong backward linkages having index values one or above are; 'agriculture,' 'manufacturing,' 'wholesale and retail trade,' 'repair of motor vehicles & motorcycles,' 'accommodation & food service activities,' 'financial & insurance activities,' 'professional, scientific & technical activities,' 'arts, entertainment & recreation,' 'administrative & support service activities,' and 'other service activities.'

Key sectors have strong backward and forward connections, meaning they have index values of one or above. Figure 2 shows four sectors with index values of 1 or above. These sectors are: 'agriculture,' 'manufacturing,' 'wholesale & retail trade,' and 'information & communication.' These sectors are the key sectors of the Jizan economy, and therefore, they can produce more impact on the whole economy than the other sectors. Policymakers should consider these essential sectors in policy-making to generate significant aggregated and disaggregated implications for the Jizan economy. On the other hand, the key sectors are also crucial for investors, as investing in these sectors could bring significant output and hence generate more income, impacting aggregate GDP.

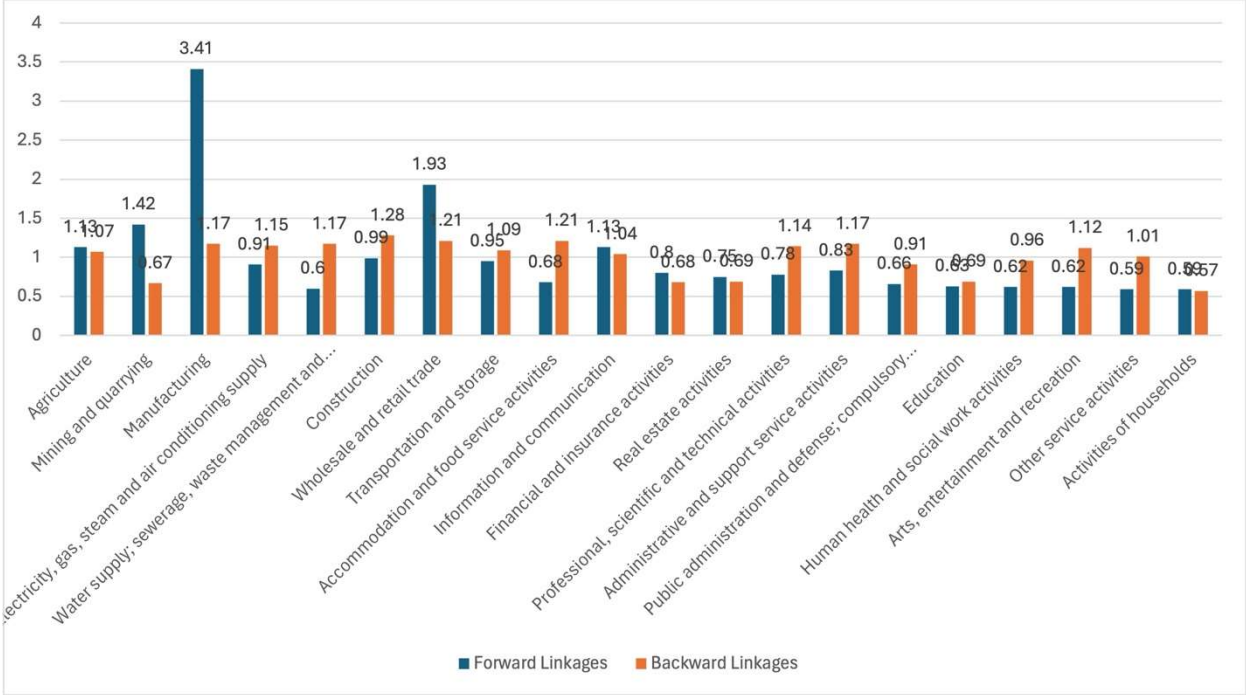

Figure 2. Indexes of forward and backward linkages

Table 1. Key sectors of the Jizan economy

		Forward Linkages		
		Strong	**Intermediate**	**Weak**
Backward Linkages	**Strong**	'Manufacturing,' 'Agriculture,' 'Wholesale & retail trade,' 'Information & communication'	'Construction,' 'Electricity, gas, steam & air conditioning,' 'Transportation & storage'	'Professional, scientific, & technical activities,' 'Accommodation & food services,' 'Administrative & support service activities,' 'Arts, entertainment & recreation,' 'Other service activities'
	Intermediate			'Defense & Public administration,' 'Social security,' 'Human health & social work activities'
	Weak	'Mining & quarrying'		'Real estate activities,' 'Financial & insurance activities,' 'Education,' 'Household activities,'

Source: Authors' Estimation

IV. DISCUSSION AND CONCLUSION:

Investors, the business community, and policymakers need to have a comprehensive understanding of interindustry connections, as they tend to favor sectors that are firmly interconnected over those with weak industry linkages. Many variables contribute to the inclination towards industries with strong direct and indirect linkages. The cyclical fluctuations of sectors are initially produced by sectors with significant linkages, resulting in a broader amplitude. This is due to the

fact that fluctuations in the demand for commodities result in heightened demand fluctuations for the inputs used in their production, which accelerates the production cycle. Secondly, industries with strong connections are more inclined to generate more produced goods and employment per unit of final demand compared to sectors with limited or inadequate industry links. Thirdly, the income distribution in the enclave sectors is unbalanced. This phenomenon is observed in emerging nations where these geographically and technologically segregated sectors primarily manufacture goods for export or for the local population associated with the enclave plants. Consequently, the significant levels of interindustry interaction imply substantial information flows among the economic sectors. Lastly, inter-industry connections are essential for the development of productivity and the transfer of technology.

Considering the discussion above, this study analyses the Jizan economy. The study first identifies the key sectors with strong backward and forward connections. The key sectors of the Jizan region are 'agriculture, forestry, fishing,' 'manufacturing,' 'wholesale and retail trade,' and 'information and communication.' Therefore, investing in these sectors will generate more output and income than other sectors. The study also conducted the impact analysis and simulated demand-side and supply-side impacts on the aggregate GDP and the incomes of all sectors. The findings confirm the significant impact of all policies simulated in the study.

The sectors related to the tourism industry, namely, the transportation and storage, arts, entertainment, and recreation sector, and accommodation and food services sector, also had a positive impact, albeit the effect was comparatively low. The reason behind the low impact is that COVID-19 restricted tourism activities, which significantly affected the transactions. Notwithstanding, the tourism industry of Jizan is vital as the region has historical monuments that date back to 8,000 BC and the Farasan Islands. This region has enormous potential to take advantage of the country's strategic location to create business hubs and construct roads, hotels, restaurants, and other entertainment hubs for tourists.

V. THEORETICAL IMPLICATIONS

The study underscores the significance of identifying sectors with significant inter-industry connections, as they are instrumental in enhancing overall productivity, job creation, and economic cycles. Furthermore, it is consistent with economic structure theories that underscore sectoral interdependence as a determinant of regional development, particularly in emerging economies such as Jizan.

VI. PRACTICAL IMPLICATIONS

Policymakers can bolster the designated crucial sectors, namely 'manufacturing,' 'agriculture,' 'information & communication,' and 'wholesale & retail trade' by promoting investments and policies that augment their productivity and interconnection with other businesses. Moreover, the private sector can strategically use this knowledge to prioritize investments in industries with robust economic connections, guaranteeing higher profits and economic robustness.

CONFLICT OF INTEREST

There is no conflict of interest between all the authors.

DATA AVAILABILITY STATEMENT

The data are not public. However, they can be provided upon request.

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