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Identification of Key Sectors in Nigeria - Evidence of Backward and Forward Linkages from Input-Output Analysis

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Abstract

The input-output table provides summary information on the industrial structure of an economy in a specific period. This table contains information on the flow of goods and services between industries and economic sectors. The backward and forward links are descriptive measures of the economic interdependence of sectors in terms of the volume of transactions. Sectors with strong backwards and forward linkages are vital sectors and play an essential role in a country's development strategy. This paper aims to construct a symmetric input-output table for Nigeria and examine the Nigerian economy's production structure by using the results applying traditional backward and forward linkage methods developed by Chenery-Watanabe and Rasmussen. Our study identifies the key sectors with backward and forward linkages as Crop and Animal production, Manufacture of Food products, Textiles, Refined petroleum products, Chemicals, Motor vehicles, Furniture, Machinery and equipment, Wholesale/retail trade, Land transport and Telecommunication. In addition, through the constructed symmetric input-output table, sector development can be further done in line with the relationship matrix, as it serves as a conduit for investment strategy, local linkage matrix and policy development. So, for the development strategy it is very important to determine which industries possess high backward and forward linkages, then stimulating final demand or primary inputs namely of these industries could positively influence the economic activity of the country. The results from this work may be used by policy makers in terms of which sectors of the economy stimulate (for example, by means of creating extra final demand, decreasing taxes, or with the help of subsiding) in order to gain better results in the sphere of economic development of Nigeria.

Keywords: input-output, productivity, backward linkages, forward linkages, supply-use table.

JEL Classification: C, E, F, H, O.

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1. Introduction

The fundamental issues of economic growth revolve around critical determinants, as well as supporting and retarding factors, which lie in the complex interactions among various forces within the economic environment.

Kuznets (1971) defines the economic growth of a country as "the long-term growth of its ability to provide its population with increasingly diversified economic products; this ability to grow is based on technological progress and the adjustment of institutions and ideologies. As a result of the increased use of technological improvement, the products of an economy's main sectors, such as manufacturing and natural resources, have increased, leading to economic growth. Key macroeconomic indicators such as GNP (Gross National Product), GDP (Gross Domestic Product), NNP (Net National Product), and other economic parameters are used to measure an economy's growth performance. Therefore, the gradual increase in GDP in the main sectors of an economy manifests the fruits of economic growth.

Real production activities promote economic growth by ensuring the continuous improvement of production methods and the discovery of new resources to create the necessary conditions for the effective use of resources. A multi-sector positive performance is essential for the growth of the overall economy, but a sector of the economy that attracts large spectrum of economic activities can stimulate the productive fibre of other sectors towards real production and provide the requisite impetus for sustainable growth of the economy. A natural resource sector, such as oil and gas, tends to generate tremendous economic activities arising from their intrinsic versatile utility value. The temptation for rent-seeking behaviour could undermine the efficient use of the natural resource and other resources of the economy thereby crippling the chances of growth of the economy. If rents, derived from natural resource extraction, are used to facilitate complacent consumption at the detriment of real production, there will be expansion of non-tradable sector activities leading to the shrinking in tradable sector activities such as manufacturing. This phenomenon is referred as the "Dutch Disease'' and it is a chronic source of slow growth due to the absence of "backward and forward" linkages among sectors of the economy (Sachs and Warner, 1997). The manufacturing sector, with a thriving service sector for support, is a vital source for economic growth through learning-by-doing, as such should have a pivotal link with the oil and gas sector in terms of resource use for real productive activities that propels the economy towards sustainable growth path.

Inter-industry linkage analysis describes a multi-industry process of complex combination of numerous and diverse resources that are transformed into usable goods and services. This process is hinged on the method of input-output that illustrates the use of resources obtained from different sectors by other sectors of the economy. The absorptive capacity (ability of capital investment or resource to yield appreciable level of return) of industries and that of the overall economy provides the impetus for interindustry linkages. The productivity level of the economy reflects on the value-adding capabilities of factors of production which hinges on the level of inter-industry linkages that exists within the economy. There is a positive relationship between the extent of inter-industry linkages and the level of output of the economy, which is an important measure of economic growth. Given that economic growth is engendered by efficient use of resources and considering that inter-industry linkages are about multi-industry absorption of resources obtained from different sectors of the economy, a formidable inter-industry linkage process is crucial for attaining economic growth.

To understand the structure of an economy, we require the understanding how each sectors of the economy is related one another. The role of industry linkages has long been an interest for economists since Hirschman (1958), who argued that interdependent structure is very important for economic development in a country. He postulated that industry linkages depend on demand and supply of inputs of intermediate goods to other economic activities. A rise or a fall in production of an economic sector would have an impact on the other sector of the economy. The magnitude of the impact depends on whether that sector has strong or weak linkages with the others. The study of industry linkages among economic sectors requires the use of an input-output table, which is compiled from a comprehensive survey of demand and supply of intermediate goods among all sectors of an economy. The input-output table could show the degree of interdependence that one economic sector depends on the other. Usually, the construction of input-output table is costly and only the government can compile the table.

Having a good input-output table enables us to predict the impact of growth in one economic sector on the other. Recently, input-output table has provided a good tool for simulation of macroeconomic policy for many countries. For example, the impact of the growth of import or export of final demand to all sectors in the economy and the impact of an increase in wage rate, consumption tax or import duties. In Nigeria, there isn't an

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updated symmetric input-output table; as the last one constructed was in 1999 by Patrick Osakwe from the Trade and Regional Integration Division, of the United Nation Economic for Africa (UNECA). For this reason, a more updated version based on the data from the Nigerian Bureau of Statistics (NBS) Database was used to construct the table. The main objective of this section of this research work is to construct an updated symmetric input-output table for Nigeria, determine the levels of inter-industry linkages in the Nigerian economy and investigate the output sector relationship.This is the unique contribution of this study, and we go further ahead to pursue the analysis required to identify the key sectors with forward and backward linkages in Nigeria. This paper is organized as follows; section 2 reviews the literature; section 3 explains the methodology; section 4 discusses the results while section 5 concludes.

2. Literature Review

We first focus on this in terms of the nexus between inter-industry linkages and economic growth and then review the studies on different growth models. Economic growth process is crucially intertwined with the transformation of resources to different forms of use. Complex interactions of several variables such as demand and supply or wages and prices, as well as a series of transactions in which actual goods and services are exchanged are involved in the transformation of resources into various uses. Given the diverse nature of contemporary economies, the process of transforming resources involves substantial mix of ideas (technology) with other factors of production such as land and labour, in addition to other resources from different activity sectors of the economy. Resources, in their natural form, have limited direct economic use in satisfying human needs but transforming them into goods and services enhances their economic value to the society. Since resources are obtained from varied natural processes based on industry/sector categorisation of the economy, the mix of productive activities by different sectors of the economy is the fountain of the transformation of resources into goods and services and the bedrock of economic growth process.

Inter-industry linkage analysis seeks to establish the multi-industry relationship that is involved in the transformation of resources into goods and services. The essence of inter-industry linkages is to describe with precision, the complex combination of numerous and diverse resources and the processes of their transformation that leads to the production of final commodities. This illuminates the different stages of production chain in that the intensity of inter-industry linkages illustrates the level of value-adding activities of factors of production, which is also a determinant of the output level of the entire economy, a sine qua non for economic growth. Basically, inter-industry linkages are of two basic types, namely backward and forward linkages; backward linkages occur when an industrial activity induces domestic production and supply of inputs needed in that activity and forward linkages occur when an industrial activity induces the utilisation of its output by other domestic production activities (Hirschman, 1958).

Technological inter-connections among various sectors of the economy could evolve from structural and spatial interdependence of the production processes of the sectors. The rational response to inducements and incentives propel the inherent capabilities of factors of production to be transmitted into technological relationships. This leads to increase in the level of activities of sectors of the economy in a self-reinforcing manner. The expansion of activity in a given industry leads to increase in demand for inputs from the sector(s) and the supplying sector(s) respond to the stimuli of increased demand by expanding production. The embodying expansionary effects of inter-industry linkages provide opportunities for economies of scale, which could translate into lower per unit cost of production.

The input-output model, based on the pioneering work of Wassily Leontief (1936), is a basic tool for analysing inter-industry linkages. The input-output table, which is anchored on double-entry structure with all industries presented in both horizontal rows and vertical columns, reveal the fabric of the economy by showing how the various sectors/industries of the economy are weaved together. The vertical column of a basic input-output table states the inputs of each of the various goods and services that are required for production in each of the respective industries. This is presented in the form of outlays of all sectors within the economy and the totals of these outlays reflect the total production for the economy (within the year under consideration). The horizontal rows represent outlays of the inputs of sectors/industries to various sectors of the economy. The total of the outlays for the columns is the total output of the economy while the total for the rows represents the extent of the supply of inputs by each of the sectors in the row. The final demand element of the vertical column usually illustrates the gross national product (GNP), which is a measure of the productive activities and by implication economic growth.

The changing pattern of inter-industry linkages, which describes inherent dynamic properties, is useful for analysing the process of economic growth (see for instance, Leontief, 1986; 31 and Bulmer Thomas, 1982; 222). Also, the high linkage hypothesis (Hirschman, 1958) has gained tremendous analytical relevance by providing insights into the determination of high linkage sectors as the potential source of growth of the overall economy (Yotopoulos and Nugent, 1973 and 1976; Laumas, 1975 and 1976; Jones, 1976 and Cella, 1984). Strategic consideration of a large activity sector identified as a key sector with high linkage relevance to other sectors can lead to gradual diffusion of value adding activities across sectors of the economy to ensure efficient utilisation of resources and generate economic growth. Endogenous growth theory and the leading sector strategy of economic growth (Currie, 1974 and 1997) give additional credence to this conception of economic growth process.

Another part of this literature review comprises of a survey of the various models of economic growth, the analytical expositions of the effects of natural resource utilisation on economic growth and perspectives on the Nigerian domestic industry and economy. Intermittently, the relevance of inter-industry linkages to the essential arguments of the economic growth theories is highlighted. This is also reflected in the discussion of the synthesis of the economic growth literature and perspectives on the Nigerian economy. The rationale for this approach is to develop a chain of various arguments on economic growth and natural resource utilisation so as to establish a channel of interrelated ideas that are relevant to the research. The various growth models have similarities in their analytical perspectives despite their different strands of argument. Therefore, surveying these models provide insights into the intricate issues that are embedded in the conceptualisation of economic growth and the critical role of natural resources in the attainment of economic growth. A synthesis of the ideas of the models created a fulcrum that was relied upon by the research to draw inferences to articulate the possibility of natural resource-driven process of sustainable economic growth. A perspective on the Nigerian economy emerged from theoretical literature and certain salient empirical issues.

From the theoretical literature, economic growth process is based on intricate interaction of variables relating to the basic components of the economic system. The main arguments of modern growth theories emanated from classical economists such as Adam Smith (1776), David Ricardo (1817), Thomas Malthus (1798), Frank Ramsey (1928), Allyn Young (1928), Frank Knight (1944) and Joseph Schumpeter (1934). The basic ideas of modern growth theory are based on competitive behavior and equilibrium dynamics, diminishing returns and their relationship to the accumulation of material and human capital, the interaction between per capita income and population growth, and the impact of technological progress on labor specialization and new products; and the discovery of production methods and the role of the market structure (monopoly and/or competition) as incentives for technological progress.

The Solow-Swan model explains economic growth process using neoclassical specification of the production function, based on the assumption of constant returns to scale, diminishing returns to each input and positive elasticity of substitution between inputs. Combining these with a constant saving rate provide a basis for general equilibrium model that predicts a conditional convergence towards a long-run steady state level of growth. The Solow model, as it is mostly referred, takes technological progress as given and investigates the effects of the division of output between consumption and investment on capital accumulation and growth. However, technology, which is taken as given (not endogenously determined) is the only factor that can change per capita long-run growth rate of the economy. The Ramsey-Cass-Koopmans (RCK) model, which is a fusion of Ramsey's (1928) earlier work with later contributions of Cass (1965) and Koopmans (1965), brought Ramsey's analysis of consumer optimisation into the stream of neoclassical growth analysis. Saving rate is endogenously determined by households' intertemporal consumption decision. The factors of production are paid their marginal products. The assumption of constant returns to scale is retained, and total income is exhausted by total products. The overlapping generation model (Diamond, 1965) differs with the RCK model only by the

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argument that the households are over time replaced by different set of households because some die and new ones are born, but the conclusions and the convergence properties are similar to the Solow and RCK models.

Endogenous growth analysis, pioneered by Arrow (1962), Uzawa (1965), and subsequently projected by Romer (1986), Rebelo (1991) and others, attempts to fill the gap created by the neoclassical assumption of exogenous technology. Ideas are the root of technology, which can be obtained from the production process. As factors of production engage in production, they learn and get to know more about what they are doing and how to do it better. Apart from this possibility of learning-by-doing, investors will be driven by profit motives to perfect the quality and varieties of their products, so they tend to explore the avenue of research and development (R&D) and this forms the basis for technology acquisition and new products are designed in the process.

The inclusion of natural resources such as oil and gas in the analysis makes the possibility of steady state growth (a constant growth rate of variables of the model) uncertain. The persistent use of the essential natural resource leads to its depletion over time which could lead to decline in output and consumption. Sustainable growth is possible only if technological change occurs and there is substitutability between capital and labour on one hand, and the exhaustible resource on the other. Technological change will ensure increase in marginal product of capital as marginal product of the resource decreases. Solow (1974) and Hartwick (1977) contend that imposing a restriction on consumption and investing the rent from natural resource exploitation will ensure sustainability of consumption path, provide a basis for intergenerational equity and long-run steady state growth.

The critical relationship between consumptions, production and factors of production, which is the bedrock of economic growth process, as established by all the different strands of economic growth expositions, underlies the significance of inter-industry linkages as a cardinal condition for generating sustainable economic growth process. The neoclassical models did not conceive sustainability as an issue, but rather regarded the optimal consumption path determined by interactions of economic forces to be inherently sustainable. For a natural resource abundant, but technologically backward economy like Nigeria, operating within the confluence of a fast growing global economy, the temptation for complacent consumption, driven by the availability of substantial revenue from the export of crude oil could subvert the drive for efficient utilisation of resources that could undermine the essence of inter-industry linkages thereby inhibiting domestic resource utilisation and crippling the process of economic growth.

3. Methodology

Analytical framework

The theoretical expositions of the standard theories of economic growth and the implication for inter-industry linkages and economic growth are the analytical platform with which this section of the research evaluates the contribution of the industry linkages to the production output and growth of the Nigerian economy. The levels of interindustry linkages within the economy illuminate the extent of value-adding activities in different industries and other sectors of the economy. Additional inferences have been drawn from the building blocks of the economic growth models as well as the implication of natural resource utilisation. A contextual analysis on the Nigerian industry and economy is carried out with reference to such related issues as technology input, production externalities, intergenerational equity, optimal depletion strategies and sustainability. Basically, the efficiency of the functions of government in harnessing domestic resources is a prerequisite to the effective contribution of industry linkages to the growth of the economy.

Type and sources of data

Data were sourced from publications of the Central Bank of Nigeria (CBN), the Nigerian National Petroleum Corporation (NNPC), the National Bureau of Statistics (NBS) in Nigeria, as well as reports of commissioned studies and publications on the Nigerian economy by various authors, national and international agencies such as the World Bank, International Monetary Fund (IMF) and the United Nations Development Programme (UNDP). The 2010 input-output data used for the computation of inter-industry linkage coefficients were sourced from the NBS while other sources provided additional data/information for the research.

The National Accounts of Nigeria 2010 published by the National Bureau of Statistics contain Supply and Use Tables (SUTs) for thirty-three sectors of the Nigerian economy for 1997,1998,1999,2000 and 2001. It has series of datasets for different years in which the current price estimates have been raised to agree with the higher levels of economic activity identified in the Supply and Use Table (SUT). The SUT is internationally recognized as the best way of estimating GDP. The tables contain thirty three sectors of the Nigerian economy as follows; Crop Production(1); Livestock(2); Forestry(3); Fishing(4); Coal Mining(5); Crude Petroleum and Natural Gas(6); Metal Ores(7); Quarrying and other Mining(8); Oil refining(9); Cement(10); Other Manufacturing(11); Electricity(12); Water(13); Building and Construction(14); Wholesale and Retail Trade(15); Hotel and Restaurants(16); Road Transport(7), Rail Transport and Pipelines(18); Water Transport(19); Air Transport(20); Other Services(21); Telecommunications(22); Post(23); Financial Institutions(24); Insurance(25); Real Estates(26); Business Services(27); Public Administration(28); Education(29); Health(30); Private Non-Profit Organisations(31); Other Services(32) and Broadcasting(33).

Method and Instrument of Analysis

Theoretical and empirical imperatives of economic growth and the implications of natural resource utilisation is the background for analytical inferences. The link between inter-industry linkages and economic growth process formed the perspective and provided insights into the expected role of the stimulating domestic productivity linkages that could facilitate the process of efficient utilisation of resources. Thus a triangular analytical building block comprising of economic growth theory, inter-industry linkage analysis and the "keyness" of a natural resource sector such as oil and gas is developed as the research platform. After reviewing the methodological strands of interindustry linkages, the values of various inter-industry linkage coefficients are computed and used for empirical discussion of inter-industry linkages in the Nigerian economy. We conduct the analysis using MS-Excel.

Methodological Background for the Analysis

The methodological approach for this paper is adopted through the work of Temurshooev (2004).

Open Leontief model. If, besides the n industries, the model also contains an "open" sector (say, households) which exogenously determines a final demand (non-input demand) for the product of each industry and which supplies a primary input (say, labour service) not produced by the n industries themselves, the model is an open model.

Let a_{ij} be the unit input coefficient denoting the amount of input i needed to produce a unit of good j (the order of the subscripts can be mnemonically recorded by the word "input-output"). Thus, to produce X_j units of good j, one needs $a_{ij}X_j$ units of input i. Knowing that X_{ij} is the input of sector i required by industry j, obviously $X_{ij} = a_{ij}X_j$. So the direct input coefficient is calculated by:

$$a_{ij} = \frac{x_{ij}}{x_j}; \quad i,j = \overline{1,n}, \tag{1}$$

The table of technical coefficients of sectors is called direct requirements table. These coefficients show the direct effects in all sectors due to a one naira (dollar) change in output in particular sector. Suppose a_{ij}=0.12. This means that each naira (dollar) worth of output in industry j will require 12 kobo (cents) worth of input from industry i. The input coefficients, thus, give the direct interindustry linkages that tie the economy together.

For each sector i the value of total production (X_i) is the sum of the intermediate demand (X_{ij}) and final demand (Y_i):

$$X_i = \sum_{j=1}^{n} X_{ij} + Y_i; \qquad i = \overline{1,n}. \tag{2}$$

Where X_{ij} symbolizes the value of sales from sector i to sector j , Y_i is the amount of sales from sector i to final demand. Using equation (2) the equilibrium of the total supply and the total demand for each good can be written as:

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$$X_{\mathrm{i}} = \sum_{j=1}^{n} a_{\mathrm{i}j} X_j + Y_i ; \quad i = \overline{1,n}. \tag{3}$$

Forming column vectors of total sectoral output and final demand, it is possible to utilize linear matrix algebra to arrive at a reduced form of input-output economy. The output column vector, X, is endogenous and the column final demand, Y, is exogenous. Given output vector $X^T= (X_1, X_2, \ldots, X_n)$, final demand vector $Y^T= (Y_1, Y_2, \ldots, Y_n)$ and the n×n matrix input coefficients $A=(a_{ij})$, the equation (3) can be expressed in the following matrix form[1]:

$$X = AX + Y \tag{4}$$

This equation is the fundamental equation of the open Leontief system, which states that the gross output, X, is the sum of all intermediary output, AX, and final demand, Y. We can solve equation (4) for X: (I - A) X = Y , where I is an identity matrix and the matrix I-A is called the technology matrix. If I-A is a non-singular matrix, i.e. if $I - A \neq 0$, then the inverse $(I - A)^{-1}$ exist and the output of each good will be given by the solution:

$$X = (I - A)^{-1} Y \tag{5}$$

The inverse of technology matrix $(I - A)^{-1}$ is called Leontief inverse or total requirements matrix. Let denote this matrix by matrix $B=(b_{ij})$. Then the total requirements coefficients of b_{ij} show how much output is required directly and indirectly from each industry in the economy for every naira's worth of output produced for final use. The total requirements table recognizes that an increase in demand for a sector's output has a greater impact on the economy then the direct effect. Industries that supply inputs to the sector experiencing the increase in demand must also increase their purchase of inputs for their production. "The indirect requirements are those output increases necessary to supply inputs to industries supplying the direct inputs plus output increases necessary to enable the expansion of those industries supplying inputs to the industries supplying inputs the industries providing the direct inputs, etc." (Emerson 1989).

Closed Leontief system. Input-output model where labour and consumption demand are included into the inter-industry transaction table, hence considered as another industry, is called a closed Leontief model. Instead of n×n matrix input coefficients $A=(a_{ij})$, the closed Leontief system is characterized by (n+1)×(n+1) dimension matrix of Ã:

$$\tilde{A} = \begin{pmatrix} A & \tilde{a}_{i,n+1} \\ \tilde{a}_{n+1,i} & \tilde{a}_{n+1,n+1} \end{pmatrix}, \tag{6}$$

Where

$$\tilde{a}_{n+1,i} = \frac{X_{n+1,i}}{X_{\mathrm{i}}}; \qquad \tilde{a}_{i.n+1} = \frac{X_{i,n+1}}{X_{n+1}}$$

The value, $\tilde{a}_{i,n+1}$ a represents the percentage of personal consumption expenditure of the household on each industry goods. The value $\tilde{a}_{n+1,i}$ is a constant coefficient technology for each industrial sector with respect to labour. It also can be interpreted as a per sectoral output value of income (wages) that the household receives from corresponding industry. The value of $\tilde{a}_{n+1,n+1}$shows inner household expenditures, household expenditures for households' services. In the closed Leontief system the output can be found in the following reduced form:

$$\tilde{X} = (I_{n+1} - \tilde{A})^{-1} \tilde{Y} \tag{7}$$

The Leontief inverse of a closed model reflects the initial, direct, indirect and induced effects. The induced effects include the effects of household income and spending. If final demand of an industrial sector increases

[1] T denotes transposition of a given matrix

this not only increases the demand for this particular industry's inputs but also for labour and thus consumption. In the closed Leontief system as industrial sector households produce consumption and provide labour. The exogenous final demand sectors in the closed Leontief system usually contain government spending, exports and investment.

Ghoshian Allocation system. Supply-driven model relates sectoral output to primary inputs and was first formulated by Ghosh (1958). The primary inputs consist of value added components. The core assumption of Ghoshian allocation system is that output distribution patterns of interindustry flows are proportionally fixed by sectoral origin. It is an alternative analogue to the Leontief demand-side input-output model and widely is used in order to find forward linkages of the sectors of the economy. Let Vi represents the total value added payments of sector i. Then a vector of total value added payments is: $V^T = (V_1, V_2 \dots V_n)$. Knowing that the following input-output identity holds:

$$X_i = \sum_{j=1}^{n} X_{ij} + V_i \quad (8)$$

Where X_i is the output of sector i and $\sum_{j=1}^{n} X_{ij}$ is the amount sector i supplies to all sectors in the economy for use of its output as inputs in their production process. With the assumption of fixed output coefficients the output coefficient matrix can be calculated as:

$$\overset{\omega}{A} = \left(\frac{X_{ij}}{X_i}\right) = \binom{\omega}{a_{ij}} \quad (9)$$

The element of $\binom{\omega}{a_{ij}}$ denotes the share of the output of sector i that flows to sector j. Since

$$(X_{ij}) = \hat{X}\,\overset{\omega}{A} \quad (10)$$

Where $\tilde{X}$ is the diagonal matrix of the sectoral values of the production, that is

$$\hat{X} = \begin{pmatrix} X^1 & 0 \cdots & 0 \\ 0 & X^2 \cdots & 0 \\ \vdots & \vdots & \vdots \\ 0 & 0 \; 0 & X_n \end{pmatrix}$$

Using this, the equation (8) can be written in the matrix form as:

$$X^T = e^T \hat{X} \overset{w}{A} + V^T \quad (11)$$

Where T stands for transposition and e is a column summation vector with all elements of ones. Since $e^T \hat{X} = X^T$ then the equation 11 can be written as

$$X^T = X^T \overset{\omega}{A} + V^T \quad (12)$$

The solution of the equation (12) with respect to sectoral output is:

$$X^T (I - \overset{\omega}{A}) = V^T$$

$$X^T = V^T (I - \overset{\varpi}{A})^{-1} \quad (13)$$

Equation (13) says that for every non-negative value added components there exists the vector of output X^T. The matrix $(I - \overset{\varpi}{A})^{-1} = (g_{ij})$ is called the Ghoshian inverse or the output inverse matrix. The element of Ghoshian inverse g_{ij} represents the change in total output of sector i in response to the one naira increase in value added available to sector j as an input in production. The exogenous variable in Ghoshian system is primary (value added) components of the economy, whereas the exogenous variable in Leontief system is final demand components.

Input-Output Multipliers. Multipliers are another means of estimating the overall change in the economy due to changes in final demand. A change in final demand generates activity in the economy as various industries buy and sell from one another. These inter-industry relations cause the total effect on the economy to exceed the initial change. The ratio of total change in the economy to the initial change in final demand is the economic multiplier. Equations (5) and (7) show multiplicative impact of change of exogenous final demand components on sectoral output.

Thus the summary measures of $(I - A)^{-1}$ and $(I - \tilde{A})^{-1}$ are termed input-output multipliers. Multipliers may be either type I or type II. The type I multipliers are used for an open model analysis and the type II multipliers are used for a closed Leontief model analysis.

The simple output multiplier of sector i is:

$$S_i = \sum_j a_{ji} , \tag{14}$$

Where and $(I_n - A)^{-1} = (a_{ij})$ and I_n is an n by n identity matrix. The value of S_i represents the total value of production (direct and indirect effects) in all sectors of an open Leontief economy that is necessary in order to satisfy one naira's worth of final demand of sectoral output of industry i.

Total output multiplier of sector i is equal:

$$T_i = \sum_j \tilde{a}_{ij} , \tag{15}$$

Where $(I_{n+1} - \tilde{A})^{-1} = (\tilde{a}_{ij})$. This is similar to the simple output multiplier except that it is with respect to the closed Leontief system and therefore, in addition to capturing the direct and indirect effects, the induced effects are considered. The induced effects can be estimated since the closed Leontief economy endogenizes households. The value of T_i shows the total value of production (direct, indirect and induced effects) in all industries in a closed Leontief economy that is necessary in order to satisfy one naira's worth of final demand of sector i. Under reasonable conditions the simple output multiplier is less or equal to the total output multiplier.

It must be noted the type I multiplier understates the overall effects by ignoring wage-earner's increased spending while the type II multipliers overstate the impacts. Because of these discrepancies, the type I and type II output multipliers are often used together to give a range of impact.

Backward and Forward Linkages

Product flows may be approached from two opposite directions, which are best characterized by the following questions (Augustinovics, 1970). "Where do they come from?" and Where do they go?" The first question is directed backwards and inquires after the composition of the inputs (per unit of output). The second is directed forwards and asks for the allocation of the production (per unit of output). Correspondingly, the input matrix A is the basis for measuring the backward linkages, the output matrix B for measuring the forward linkages (note that in this work we indicated output matrix by $\overset{\omega}{A}$ since matrix B represents Leontief inverse).

The examination of backward and forward linkages by various measures enables one to identify leading sectors in the economy and investigate the structure of production of the economy.

Backward linkages are defined as the column sums of the Leontief-inverse from the demand-driven input-output model. Forward linkages are defined as the row sums of the Ghosh-inverse from the supply-driven input-output model. Besides these models, direct input and direct output coefficients, and hypothetical extraction of sectors from the demand-driven and supply-driven models are used to define key sectors (Oosterhaven, 2008).

Chenery-Watanabe method

Based on the input-output model, the first attempts to supply quantitative evaluation of backward and forward linkage were made by Chenery and Watanabe (1958) in their studies on the international comparison of the structure of production. This method is based on the distinction between direct and indirect use of factors of production. The first one is the backward linkage and denotes the dependence of a given industry on other industries. It measures the indirect use of factors of production and for a given industry can be found by calculating the ratio of total inputs to the value of total production. The second measure is forward linkage and denotes the dependence of other industries on a given industry. It represents the direct use of factors of production and can be computed by finding the ratio of intermediate demand to total demand for a given product. The Chenery-Watanabe (CW) backward linkage is simply the sum of the appropriate column of a matrix of technical coefficients A, since its elements show where the production materials for the production of this sector come from. The strength of the backward linkages of a sector j is defined as:

$$BL_j^{CW} = \sum_{i=1}^{n} \frac{X_{ij}}{X_j} = \sum_{i=1}^{n} a_{ij} \quad (16)$$

Where BL_j^{CW} denotes the backward linkage of sector j for CW method, X_{ij} is the magnitude of sector i's output used as production input by sector j, X_j is the output of sector j, and a_{ij} is the input coefficient of sector j to sector i.

The CW forward linkage is the sums of rows of matrix of the output coefficients that show the share of the production of an individual sector used in the production of all sectors. The strength of the forward linkages of sector i may be defined as:

$$FL_i^{CW} = \sum_{j=1}^{n} \frac{X_{ij}}{X_i} = \sum_{j=1}^{n} \overset{\varpi}{a}_{ij} \quad (17)$$

Where FL_i^{CW} denotes the forward linkage of sector i for CW method, $\overset{\varpi}{a_{ij}}$. is the output coefficient of sector i to sector j. In the matrix form equations (16) and (17) can be written correspondingly as:

$$BL^{CW} = éA \quad (16')$$

$$FL^{CW} = \overset{\varpi}{Ae}. \quad (17')$$

Where e is the column summation vector (that is e_i=1 for all i) and a prime denotes transposition.

Using the two indicators, i.e. the total intermediate input coefficients and total intermediate output coefficients[2], Chenery and Watanabe compared the structure of production for four countries (the United States, Japan, Norway, and Italy).

Based on the direct input or output coefficients, the CW method measures only the first round of effects generated by the interrelationships between sectors. So these indices are also called direct backward and forward linkages.

Different industries have varying degrees of importance in bringing about structural changes in the economy. However, the CW method has some disadvantages. "First, they only considered the direct impact of a specific industry's output increase and ignored the indirect effects that may be very important in many cases. Second, they are only average indicators and do not reveal the degree of asymmetry in the industry's input or delivery mode. Third, these are unweighted indexes, which means that all sectors are equally important in the input-output table. Therefore, to identify the key sectors in an economy, a weighting structure is needed to bring out the relative strength of various industries in the economy" (Prem, 1975).

In a demand-driven input-output model, final demand is an exogenous variable, so the share of final demand across industries relative to total final demand will be a good weight for determining the relative strength of the backward linkages of different sectors of the economy. In a supply-based input-output model, value-added (primary input) is an exogenous variable, so an excellent weighted measure would be the share of value-added for a given sector relative to total value added in the economic sector, which highlights the relative strength of the forward linkages of different sectors of the economy. The elements of the final demand weighted direct requirements matrix Aw are denoted by a_{ij}^{w}, where

$$a_{ij}^{w} = a_{ij} \frac{Y_j}{\sum_{j=1}^{n} Y_j} \quad (18)$$

Accordingly, the elements of value added weighted direct output matrixes are $\overset{\omega}{A}w$ denoted by $\overset{\varpi_w}{a_{ij}}$, where:

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[2] Chenery and Watanabe labelled backward and forward linkages as μ and ω respectively.

$$\overset{\varpi}{a}{}^{w}_{ij} = \overset{\varpi}{a}_{ij} \frac{V_i}{\sum_{i=1}^{n} V_i} \quad (19)$$

Recall that Y_i stands for final demand for sector i's output and V_i stands for value added (primary inputs) of sector i. Then with the use of weighted direct input and output coefficients CW backward and forward linkages in equations (16') and (17') can be written as:

$$BL^{CW} = \acute{e}A^{w} \quad (20)$$

$$FL^{CW} = \overset{\varpi}{A}{}^{w} e \quad (21)$$

Equation (20) is the column sum of the final demand weighted input coefficients, written as row vector, and equation (21) is the row sum of value added weighted output coefficients, written as column vector.

Rasmussen method

As we mentioned earlier the main criticism of CW method is that it considers only direct linkages between industries but neglects indirect which are more important in some sectors. Rasmussen (1956) proposed to use the column and row sums of the Leontief inverse, $(I - A)^{-1}$, to measure inter-sectoral linkages. The backward linkage, based on the Leontief inverse matrix, is simply defined as the column sums of the inverse matrix, i.e.,

$$BL_j^R = \sum_{i=1}^{n} b_{ij} \quad (22)$$

Where b_{ij} is the ij-th element of Leontief inverse that is denoted by B, i.e. $B = (I - A)^{-1}$. Sector j's backward linkage, BL_j^R, reflects the effects of an increase in final demand of sector j on overall output. In other words, it measures the extent to which a unit change in final demand for the product of sector j causes production increases in all sectors. It should represent the power of the sectoral backward linkage. That is why Rasmussen called this sum the index of the power of dispersion.

Similarly, the corresponding forward linkage can be defined as the sum of the rows of the Leontief inverse matrix. Thus a measure of forward linkage of sector i is as:

$$FL_i^R = \sum_{j=1}^{n} b_{ij} \quad (23)$$

It measures the magnitude of output increase in sector i, if the final demand in each sector were to increase by one unit. In other words, it measures the extent to which sector i is affected by an expansion of one unit in all sectors. Rasmussen named this sum the index of sensitivity of dispersion.

Rasmussen's measures take into account indirect effects. However, there is still problem with his forward linkage. Jones argued, it "measures direct plus indirect effects on supplier industries, but not on user industries: i.e., backward but not forward linkages". In relation to Rasmussen forward linkage (equation (23)), Jones argued that "it is not very enlightening to ask what happens to an industry if all industry, large or small, are to expand by identical unit increments in final demand" (Jones, 1976).

We call the Ghoshian inverse the output inverse matrix and express it as $G = (I - \overset{\varpi}{A})^{-1} = (g_{ij})$. So forward linkages based on the output coefficient matrix can be written as:

$$FL_i^{Ro} = \sum_{j=1}^{n} g_{ij} \quad (24)$$

Where g_{ij} is the ij-th element of Ghoshian inverse, FL_i^{Ro} denotes the forward linkage of sector i. It measures the extent to which a unit change in the primary input (value added) of all sectors causes production increases of sector i. In the matrix form equations (22) and (24) may be written as:

$$BL^{R} = \acute{e}(I - A)^{-1} = \acute{e}B \quad (25)$$

$$FL^{Ro} = (I - \overset{\varpi}{A})^{-1} e = Ge \quad (26)$$

The elements of the final demand weighted Leontief inverse are denoted by b_{ij}^{w}, where

$$b_{ij}^{w} = b_{ij} \frac{Y_j}{\sum_{j=1}^{n} Y_j} \quad (27)$$

The total requirements coefficients matrix is weighted by final demand to avoid a possible bias. Then the column sum of weighted Leontief inverse is defined as the weighted Rasmussen backward linkage and is calculated as:

$$BL_j^R = \sum_{i=1}^{n} b_{ij}^{w} \quad (28)$$

It shows the input requirements for a unit increase in the final demand for sector j's output given each sector's share in total final demand. Expressing the backward linkage as an index (that is in normalized values) is as follows:

$$BL^R = \frac{(\frac{1}{n}) BL_j^R}{(\frac{1}{n^2})} = \frac{BL_j^R}{(\frac{1}{n}) \sum_{j=1}^{n} BL_j^R} \quad (29)$$

The numerator in equation (29) measures the average stimulus to other sectors, according to each sector's share in total final demand, resulting from a unit increase in the final demand for sector j's output. The denominator measures the average stimulus to the whole economy resulting from a unit increase in the final demand for the output of all sectors.

The index of weighted forward linkage is given by

$$FL^R = \frac{(\frac{1}{n}) FL_i^{Ro}}{(\frac{1}{n^2}) \sum_{j=1}^{n} BL_i^{Ro}} = \frac{FL_i^{Ro}}{(\frac{1}{n}) \sum_{i=1}^{n} FL_i^{Ro}} \quad (30)$$

Where the sum of the elements of Ghoshian inverse in row *i*:

$$FL_i^{Ro} = \sum_{j=1}^{n} g_{ij} \frac{V_i}{\sum_{i=1}^{n} V_i} = \sum_{j=1}^{n} g_{ij}^{w} \quad (31)$$

shows the increase in the output of sector i needed to supply the inputs required to produce an additional unit of final demand output, given each sector's share in total value added.

The forward linkage would be subject to bias noted in Chatterjee (1989) if the total requirements matrix wasn't weighted. This is because "for the row sum to measure the forward linkage in an unbiased fashion, it is necessary to make the assumption that the demands for all sectors increase by one unit. All sectors are unlikely in practice to be of equal importance in the structure of demand, so if a small sector j uses inputs from sector i disproportionately largely, the forward linkage index will be blown up artificially by the assumption of equal expansion of all sectors" (Chatterjee 1989). In the case of supply-driven input-output model the same is true. That is the forward linkage is based on the assumption of a unit increase in primary inputs for all sectors. However, all sectors are not of equal importance in the structure of economy value added (primary inputs). So weighting the total requirements matrix avoids this problem.

Key sectors for the economic development of a region or a country have been defined as sectors with above average backward and forward linkages. The linkage indicators are normalized and calculated by using following formulas:

$$NBL = nBL_j / \Sigma BL_j$$

$$NFL = nFL_j / \Sigma FL_j \quad (32)$$

Where

NBL = $\{BL_j\}$ - vector of normalized values of backward linkages,

NFL = $\{FL_i\}$ - vector of normalized values of forward linkages,

n - Number of sectors in IOT.

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Linkage indicators for all sectors are grouped into four categories. If the values of both backward and forward linkages of sectors are above the corresponding average, these sectors are called as key sectors. If only the backward linkages of sector are greater than the average, this sector is called strong backward linkages. If only the forward linkages of sector are greater than the average, this sector is called strong forward linkages. The fourth group refers to the weak linkages category. In this case, the values of sector's backward and forward linkages are less than one.

4. Presentation and Analysis of Results

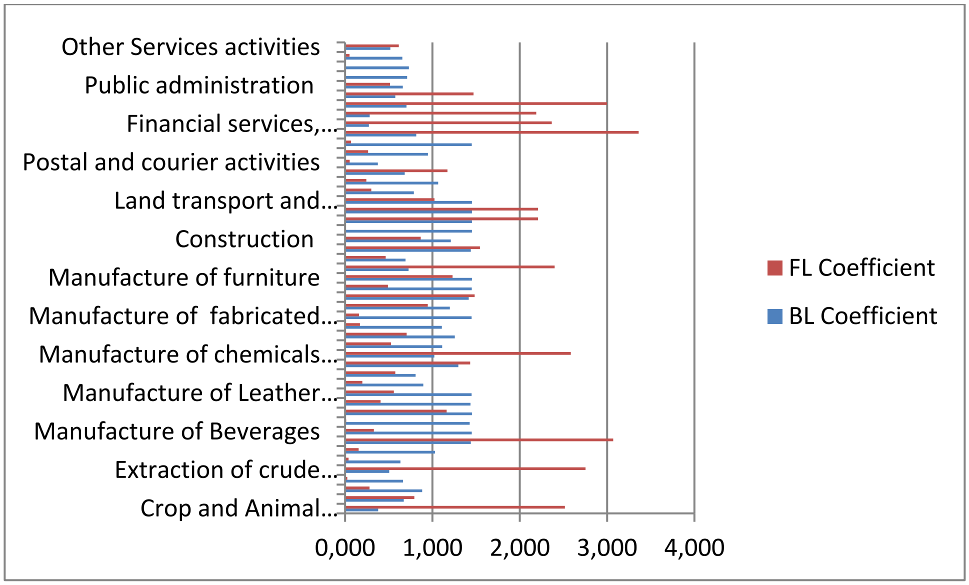
The analysis seeks to unravel the structural pattern of inter-industry linkages using the results obtained for the various linkage measures. Linkage analysis has been calculated for the Nigerian economy using the results from the symmetric I-O table constructed which transformed from supply and use tables based on fixed product sales structure assumption. The 2010 Supply and Use Table was used, and an aggregated 49 sectors and sub-sectors level was constructed from the SU table.

The empirical analysis is based on the Input-Output Table constructed by the researcher. The input-output transactions table is shown in table 1 in the appendix. All commodity flows between industries and other economic agents in the input-output table are in millions of naira and recorded in basic prices. The basic price of a good or service is the amount receivable by the producer from the purchaser minus any tax payable and plus any subsidy receivable (except subsidy on import). The producer price is the amount receivable by the producer from purchaser minus any deductible goods and services tax invoiced to the purchaser. The purchaser's price is the amount paid by the purchaser, excluding any deductible goods and services tax in order to take delivery of a unit of a commodity. In the case of goods, the purchaser's price includes any trade margins and transport charges paid by the purchaser. Both basic and producer prices exclude transport charges invoiced separately by the producer.

Table 3 in the appendix shows the normalized values of forward and backward linkages of forth-nine sectors and sub-sector in the Nigerian economy. Here the direct input and output coefficients as well as weighted directed input and output coefficients are used. In order to find backward and forward linkages, first the input and output coefficients matrices were constructed.

According to the size of the various linkage indicators, all sectors of an economy may be grouped into four categories. If the values of both backward linkage and forward linkage of a sector are all above the corresponding average (that is the normalized values of both backward and forward linkages is greater than 1), the sector is called as "key" sector. If only the backward linkages of a sector are greater than the average (only the normalized value of backward linkages is greater than one), the sector can be termed a strong backward linkages sector. Similarly, if only the forward linkages of a sector are greater than the average (i.e. only the normalized value of forward linkages is greater than one), the sector is called a strong forward linkages sector. The fourth group refers to the weak linkage category. This is the case where a sector's backward linkages and forward linkages are all less than the averages, i.e. the normalized values of backward and forward linkages are smaller than one. Table 3 shows these four groups of sectors according to CW method.

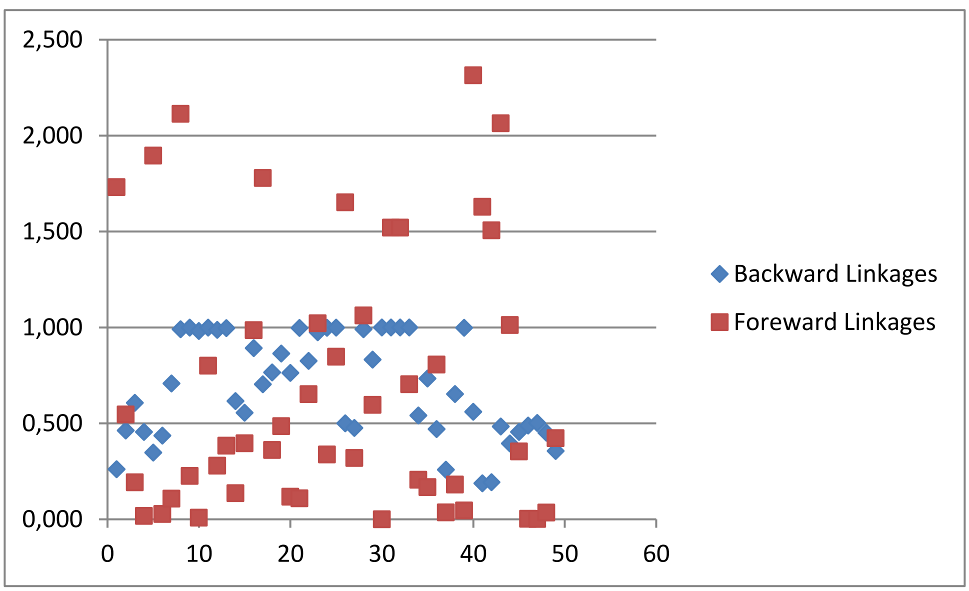
As we see in the 2010 data in Nigeria, according to the CW method there were ten key sectors. The sector is defined as the key sector if one of the weighted linkages or unweighted linkages or both of them show the strong backward and forward linkages. These key sectors are: Manufacture of Food Products, Manufacture of Textiles, Manufacture of coke and refined products, manufactures of chemicals and chemical products, manufacture of motor vehicles, trailer and semi-trailers, manufacture of furniture, Water collection, waste collection, remediation & sewage, wholesale trade, retail trade and land transport & transport via pipeline. Crop and animal production, Manufacture of food products and Extraction of crude oil are defined as key sectors by weighted linkages since these sectors contribute largely to the economy output and value added. It shares to demand and primary inputs account for 20.3%, 11.1% and 18.8%, respectively (see Table 2 in appendix). The unweighted linkages define crop and animal production and extraction of crude oil as sectors with strong forward linkages. In addition, the diagrams below show that a large majority of industries and sub-sectors in Nigeria have a lower forward linkage with the coefficients of forward linkages smaller than 1.



Source: Author's calculation based on Constructed I-O Table.

Figure 1. Coefficients of Backward and Forward Linkages Using C.W Method

The sectors with strong backward linkages are Other mining and quarrying, manufacture of beverages, manufacture of tobacco, manufacture of wearing apparel, manufacture of leather footwear, manufacture of rubber and plastics, manufacture of other non-metallic mineral products, manufacture of basic metals, manufacture of fabricated metals, manufacture of electronics and optical products, manufacture of machinery and equipment, construction, repair of motor vehicles and motorcycles, air transport and publish activities. Table 3 also shows that about eighteen sectors in the data used, had strong forward linkages and the rest sectors had weak linkages.



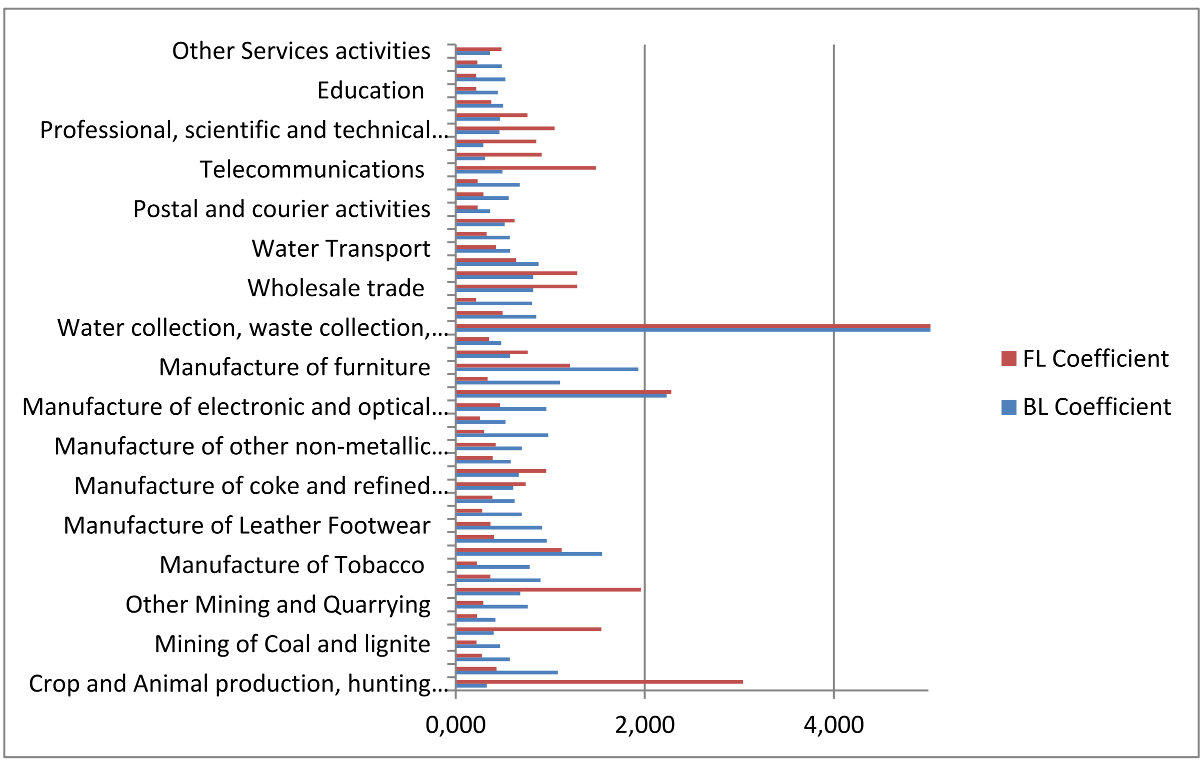
Source: Author's calculation.

Figure 2. Clusters of Industry Linkages in Nigeria

According to weighted Chenery-Watanabe method, the highest backward linkage sector is the repair of motor vehicle industry, while the highest under the unweighted linkages is the construction industry (see Table 4). The second ranking in the weighted backward linkages is the Manufacture of food products, while for unweighted linkages it is the Wholesale trade industry. The lowest rankings of the weighted and unweighted backward linkages have Water collection industry and financial services. With respect to forward linkages, the Crop and animal production industry have the highest weighted forward linkages while the Telecommunication industry has the highest unweighted forward linkages. It appears that Repair of motor vehicle industries both have the lowest forward linkage in both the weighted and unweighted classification.

Table 5 shows the normalized values of backward and forward linkages of industries of Nigeria for 2010 based on the Rasmussen method. The key sectors have been defined in the same way as in previous section and have been shaded. In comparison with the CW method there are four key industries for Rasmussen method. However, according to Rasmussen method Manufacture of food products is no longer a key sector and is defined as a sector with strong forward linkages. It may be the result of insignificancy of indirect effects in this sector. The new sectors among key sectors are Manufacture of Textiles, Manufacture of motor vehicles, trailer and semi-trailers, Manufacture of furniture and Water collection and waste collection. These sectors appear to be part of the keys sectors under the CW method and these sectors contribute to a lot to the final demand and value added of the economy.

The Water and waste collection industry has the strongest backward and forward linkages with respect to the weighted and unweighted classification under the Rasmussen method. The Construction and Crop production industry has the highest backward and forward linkages under the weighted classification. Moreover, the Manufacture of Motor vehicle industry has second strongest backward linkages under the Unweighted and weighted classification. The least strong backward and forward linkages under the weighted classification are the Water Collection industry and the Mining of metal ores. Some weighted ranking is missing at this is due to lack of data for comprehensive share in value added.



Source: Author's calculation based on Constructed I-O Table.

Figure 3. Coefficients of Backward and Forward Linkages Using Rasmussen Method

The first ranking in weighted backward and forward linkages have Crop and animal production, hunting and related service activities having similar ranking positions for weighted CW and Rasmussen method. This shows the significance of this industry to the Nigerian economy (see appendix2 table 2). As for backward linkages there are also some differences in ranking positions of some sectors. For example, Water collection, waste collection and Sewage Industry is ranked as the strongest with unweighted backward linkage whereas weighted backward linkages show that Construction Industry is the strongest in terms of backward linkages among the forty-nine sectors. This picture is in accordance with the rankings given to these above industries by weighted and unweighted Rasmussen backward linkages.

5. Conclusion

This work has investigated the production structure and inter-sectoral linkages of the Nigerian economy based on 2010 data. This analysis was undertaken at the relatively disaggregated level of industries for which data are available. These are forty-nine production sectors and sub-sector. This work is an attempt to empirically identify key sectors and industry linkages. Type I and type II output multiplier and indices of backward and forward linkages based on Chenery-Watanabe and the Rasmussen Methods were calculated. Backward and forward linkages show how much each industry buys and sells to other industries, directly and indirectly caused by the unit increase in final demand and primary inputs. So, for the development strategy it is very important to determine which industries possess high backward and forward linkages, then stimulating final demand or primary inputs namely of these industries could positively influence the economic activity of the country.

In order to find out key sectors of the Nigerian economy the results of CW and Rasmussen methods are presented together in Table 6. Then it is taken into account that a key sector is a sector which is placed into this group by at least one method used. In this way it had been found out that in 2010 in the Nigerian economy there were thirteen sectors that belonged to the category of key sectors. These are Crop and Animal production, Manufacture of Food products, Manufacture of Textiles, Manufactured of refined petroleum products, Manufacture of chemicals, Manufacture of motor vehicles, Manufacture of furniture, Manufacture of machinery and equipment, wholesale trade, retail trade, Land transport and Telecommunication. Investment in these sectors would initiate economic development due to the inter-relations with other industries.

All sectors are classified using the international standard for industry classification (ISIC) and their numbers are also provided for verification. The present work may be used by policy makers in terms of which sectors of the economy stimulate (for example, by means of creating extra final demand, decreasing taxes, or with the help of subsiding) in order to gain better results in the sphere of economic development of Nigeria. However, it must be mentioned that the analysis is based on the assumption of fixed input and output coefficients, i.e. they remained unchanged since 2010. In a future study, one may eliminate this limitation by allowing for time-varying coefficients in a Computable General Equilibrium (CGE) or other dynamic frameworks.

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Appendix

Table 1. Excerpt of Inter-Industry Transaction Table of Nigeria for 2010 year in basic prices (in thousands of Naira)

The full table can be found here https://www.academia.edu/70917232/Table_for_I_O_paper

Table 2. Some Input-Output Coefficient Table

The full table can be found here https://www.academia.edu/70917232/Table_for_I_O_paper

Table 3. Backward and Forward Linkages Using the Chenery-Watanabe Method

ISIC	Activities	Backward Linkages	BL Coefficient	Category	Forward Linkages	FL Coefficient	Category
01	Crop and Animal production, hunting and related service activities	0.261	0.379	wB	1.732	2.516	sF
02	Forestry and logging	0.463	0.672	wB	0.546	0.794	wF
03	Fish and aquaculture	0.608	0.883	wB	0.193	0.281	wF
05	Mining of Coal and lignite	0.456	0.662	wB	0.018	0.026	wF
06	Extraction of crude petroleum and natural gas	0.348	0.506	wB	1.896	2.754	sF
07	Mining of metal ores	0.436	0.634	wB	0.028	0.041	wF
08	Other Mining and Quarrying	0.708	1.028	sB	0.108	0.156	wF
10	Manufacture of Food Products	0.991	1.440	sB	2.114	3.071	sF
11	Manufacture of Beverages	0.999	1.451	sB	0.226	0.329	wF
12	Manufacture of Tobacco	0.982	1.426	sB	0.009	0.013	wF
13	Manufacture of Textiles	1.000	1.452	sB	0.801	1.163	sF
14	Manufacture of Wearing apparel	0.988	1.435	sB	0.280	0.406	wF
15	Manufacture of Leather Footwear	0.997	1.449	sB	0.384	0.558	wF
16	Manufacture of wood and wood products	0.617	0.896	wB	0.136	0.198	wF
17	Manufacture of paper and paper products	0.555	0.807	wB	0.396	0.576	wF
19	Manufacture of coke and refined petroleum products	0.893	1.297	sB	0.986	1.432	sF
20+21	Manufacture of chemicals and chemical products and pharmaceutical preparations	0.704	1.023	sB	1.779	2.584	sF
22	Manufacture of rubber and plastics products	0.766	1.112	sB	0.361	0.525	wF
23	Manufacture of other non-metallic mineral products including Cement	0.865	1.256	sB	0.486	0.706	wF
24	Manufacture of basic metals	0.763	1.109	sB	0.118	0.171	wF
25	Manufacture of fabricated metal products	0.998	1.449	sB	0.109	0.158	wF
26+27	Manufacture of electronic and optical products and electrical equipment	0.826	1.200	sB	0.652	0.948	wF
29	Manufacture of motor vehicles, trailers and semi-trailers	0.975	1.416	sB	1.022	1.484	sF

Table 3 (cont.). Backward and Forward Linkages Using the Chenery-Watanabe Method

ISIC	Activities	Backward Linkages	BL Coefficient	Category	Forward Linkages	FL Coefficient	Category
28+30	Manufacture of machinery and equipment	0.998	1.450	sB	0.338	0.492	wF
31	Manufacture of furniture	1.000	1.452	sB	0.847	1.231	sF
32	Other Manufacturing	0.501	0.728	wB	1.652	2.401	sF
35	Electricity, gas, steam and air conditioning supply	0.477	0.692	wB	0.320	0.465	wF
36-39	Water collection, waste collection, Remediation, and Sewage	0.991	1.440	sB	1.063	1.545	sF
41-43	Construction	0.833	1.210	sB	0.596	0.866	wF
45	Repair of motor vehicles and motorcycles	1.000	1.453	sB	0.000	0.000	wF
46	Wholesale trade	1.000	1.453	sB	1.521	2.210	sF
47	Retail trade	1.000	1.453	sB	1.521	2.210	sF
49	Land transport and transport via pipelines	1.000	1.453	sB	0.705	1.024	sF
50	Water Transport	0.542	0.787	wB	0.206	0.300	wF
51	Air Transport	0.734	1.066	sB	0.168	0.243	wF
52	Warehousing and support activities for transportation	0.470	0.683	wB	0.807	1.172	sF
53	Postal and courier activities	0.258	0.375	wB	0.036	0.052	wF
55+56	Accommodation and Food and beverage service activities	0.653	0.949	wB	0.181	0.263	wF
58+59+60	Publishing activities, Motion picture, video and television programme production, sound recording and broadcasting activities	0.999	1.451	sB	0.046	0.067	wF
61	Telecommunications	0.561	0.815	wB	2.315	3.362	sF
64+65	Financial services, insurance and pension funding	0.188	0.273	wB	1.629	2.367	sF
68	Real estate activities	0.194	0.281	wB	1.507	2.189	sF
69-75	Professional, scientific and technical activities	0.484	0.703	wB	2.064	2.999	sF
77	Administrative and support service activities	0.395	0.575	wB	1.013	1.471	sF
84	Public administration	0.456	0.662	wB	0.354	0.514	wF
85	Education	0.489	0.710	wB	0.002	0.004	wF
86-88	Human health and social work activities	0.502	0.730	wB	0.002	0.003	wF
90-93	Creative, arts and entertainment activities	0.451	0.655	wB	0.035	0.051	wF
94-99	Other Services activities	0.356	0.518	wB	0.423	0.615	wF

Note: wB- Weak Backward, wF- Weak Forward, sF- Strong Forward, sB- Strong Backward.

Table 4. Rankings of Backward and Forward Linkages for 2010

		Backward Linkages				Forward Linkages			
		CW		Rasmussen		CW		Rasmussen	
ISIC	Activities	UBL	WBL	UBL	WBL	UFL	WFL	UFL	WFL
01	Crop and Animal production, hunting and related service activities	46	3	47	3	6	1	2	1
02	Forestry and logging	38	39	6	26	22	12	23	18
03	Fish and aquaculture	28	34	30	35	34	14	39	16
05	Mining of Coal and lignite	39	46	39	46	45	34	46	34
06	Extraction of crude petroleum and natural gas	45	4	44	4	4	2	5	2
07	Mining of metal ores	42	47	43	47	44	33	44	35
08	Other Mining and Quarrying	24	33	18	34	40	28	37	24
10	Manufacture of Food Products	13	2	21	5	2	36	4	—
11	Manufacture of Beverages	7	18	11	18	32	36	31	—
12	Manufacture of Tobacco	15	42	17	43	46	36	45	—
13	Manufacture of Textiles	5	15	4	13	18	36	10	—
14	Manufacture of Wearing apparel	14	36	8	37	31	36	26	—
15	Manufacture of Leather Footwear	11	14	10	16	26	36	30	—
16	Manufacture of wood and wood products	27	32	19	32	37	21	38	20

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Table 4 (cont.). Rankings of Backward and Forward Linkages for 2010

17	Manufacture of paper and paper products	30	41	24	41	25	25	28	29
19	Manufacture of coke and refined petroleum products	17	11	25	14	15	10	17	11
20+21	Manufacture of chemicals and chemical products and pharmaceutical preparations	25	22	23	23	5	16	12	22
22	Manufacture of rubber and plastics products	21	37	26	40	27	23	27	26
23	Manufacture of other non-metallic mineral products including Cement	18	23	20	27	23	18	25	21
24	Manufacture of basic metals	22	27	7	25	38	27	35	25
25	Manufacture of fabricated metal products	10	28	32	38	39	36	40	—
26+27	Manufacture of electronic and optical products and electrical equipment	20	9	9	9	20	30	22	33
29	Manufacture of motor vehicles, trailers and semi-trailers	16	7	2	2	13	19	3	19
28+30	Manufacture of machinery and equipment	9	17	5	15	29	36	33	—
31	Manufacture of furniture	6	40	3	29	16	36	9	—
32	Other Manufacturing	33	12	27	11	7	11	15	13
35	Electricity, gas, steam and air conditioning supply	36	45	38	45	30	13	32	17
36-39	Water collection, waste collection, Remediation, and Sewage	12	49	1	49	12	15	1	9
41-43	Construction	19	1	13	1	21	7	20	7
45	Repair of motor vehicles and motorcycles	1	19	16	20	49	36	49	—
46	Wholesale trade	2	5	14	6	9	36	8	—
47	Retail trade	3	5	15	7	9	36	7	—
49	Land transport and transport via pipelines	4	10	12	10	19	36	18	—
50	Water Transport	31	38	28	36	33	31	24	32
51	Air Transport	23	35	29	39	36	26	34	27
52	Warehousing and support activities for transportation	37	30	34	28	17	20	19	23
53	Postal and courier activities	47	48	45	48	42	32	41	31
55+56	Accommodation and Food and beverage service activities	26	26	31	31	35	17	36	15
58+59+60	Publishing activities, Motion picture, video and television programme production, sound recording and broadcasting activities	8	42	22	12	41	32	42	—
61	Telecommunications	29	8	36	8	1	3	6	3
64+65	Financial services, insurance and pension funding	49	25	48	22	8	6	13	6
68	Real estate activities	48	24	49	24	11	4	14	4
69-75	Professional, scientific and technical activities	35	16	41	17	3	5	11	5
77	Administrative and support service activities	43	21	40	19	14	22	16	28
84	Public administration	40	13	35	12	28	8	29	8
85	Education	34	20	42	21	47	29	47	12
86-88	Human health and social work activities	32	31	33	33	48	35	48	30
90-93	Creative, arts and entertainment activities	41	43	37	42	43	24	43	14
94-99	Other Services activities	44	29	46	30	24	9	21	10

Note: UBL- Unweighted Backward Linkages, WBL- Weighted Backward Linkages, UFL- Unweighted Forward Linkages, WFL- Weighted Forward Linkages.

Table 5. Backward and Forward Linkages Using Rasmussen Method

ISIC	Activities	Backward Linkages	BL Coefficient	Category	Forward Linkages	FL Coefficient	Category
01	Crop and Animal production, hunting and related service activities	1.52	0.328	wB	14.09	3.041	sF
02	Forestry and logging	5.01	1.081	sB	2.00	0.433	wF
03	Fish and aquaculture	2.65	0.572	wB	1.28	0.276	wF
05	Mining of Coal and lignite	2.18	0.470	wB	1.03	0.221	wF
06	Extraction of crude petroleum and natural gas	1.86	0.402	wB	7.14	1.541	sF
07	Mining of metal ores	1.95	0.420	wB	1.05	0.226	wF
08	Other Mining and Quarrying	3.53	0.762	wB	1.35	0.292	wF
10	Manufacture of Food Products	3.16	0.683	wB	9.08	1.959	sF
11	Manufacture of Beverages	4.16	0.898	wB	1.70	0.367	wF
12	Manufacture of Tobacco	3.63	0.782	wB	1.04	0.224	wF
13	Manufacture of Textiles	7.17	1.548	sB	5.20	1.121	sF
14	Manufacture of Wearing apparel	4.47	0.964	wB	1.88	0.405	wF
15	Manufacture of Leather Footwear	4.24	0.915	wB	1.70	0.367	wF
16	Manufacture of wood and wood products	3.24	0.700	wB	1.29	0.279	wF
17	Manufacture of paper and paper products	2.89	0.623	wB	1.80	0.388	wF
19	Manufacture of coke and refined petroleum products	2.82	0.607	wB	3.43	0.740	wF
20+21	Manufacture of chemicals and chemical products and pharmaceutical preparations	3.09	0.667	wB	4.43	0.956	wF
22	Manufacture of rubber and plastics products	2.70	0.583	wB	1.81	0.392	wF
23	Manufacture of other non-metallic mineral products including Cement	3.24	0.699	wB	1.96	0.423	wF
24	Manufacture of basic metals	4.53	0.979	wB	1.39	0.301	wF
25	Manufacture of fabricated metal products	2.44	0.527	wB	1.19	0.256	wF
26+27	Manufacture of electronic and optical products and electrical equipment	4.44	0.958	wB	2.18	0.470	wF
29	Manufacture of motor vehicles, trailers and semi-trailers	10.34	2.230	sB	10.57	2.280	sF
28+30	Manufacture of machinery and equipment	5.12	1.104	sB	1.56	0.337	wF
31	Manufacture of furniture	8.95	1.932	sB	5.60	1.209	sF
32	Other Manufacturing	2.66	0.575	wB	3.53	0.762	wF
35	Electricity, gas, steam and air conditioning supply	2.23	0.481	wB	1.64	0.353	wF
36-39	Water collection, waste collection, Remediation, and Sewage	68.16	14.708	sB	77.61	16.749	sF
41-43	Construction	3.95	0.852	wB	2.30	0.497	wF
45	Repair of motor vehicles and motorcycles	3.75	0.809	wB	1.00	0.216	wF
46	Wholesale trade	3.80	0.820	wB	5.96	1.285	sF
47	Retail trade	3.80	0.820	wB	5.96	1.285	sF
49	Land transport and transport via pipelines	4.07	0.878	wB	2.96	0.639	wF
50	Water Transport	2.66	0.574	wB	1.98	0.427	wF
51	Air Transport	2.66	0.573	wB	1.51	0.327	wF
52	Warehousing and support activities for transportation	2.40	0.518	wB	2.89	0.624	wF
53	Postal and courier activities	1.69	0.365	wB	1.08	0.233	wF
55+56	Accommodation and Food and beverage service activities	2.60	0.561	wB	1.36	0.293	wF
58+59+60	Publishing activities, Motion picture, video and television programme production, sound recording and broadcasting activities	3.14	0.678	wB	1.07	0.232	wF
61	Telecommunications	2.30	0.495	wB	6.88	1.484	sF
64+65	Financial services, insurance and pension funding	1.44	0.311	wB	4.22	0.910	wF
68	Real estate activities	1.35	0.292	wB	3.94	0.851	wF
69-75	Professional, scientific and technical activities	2.14	0.463	wB	4.85	1.046	wF
77	Administrative and support service activities	2.17	0.469	wB	3.52	0.759	wF

Table 5 (cont.). Backward and Forward Linkages Using Rasmussen Method

ISIC	Activities	Backward Linkages	BL Coefficient	Category	Forward Linkages	FL Coefficient	Category
84	Public administration	2.32	0.501	wB	1.75	0.377	wF
85	Education	2.07	0.446	wB	1.00	0.216	wF
86-88	Human health and social work activities	2.43	0.525	wB	1.00	0.216	wF
90-93	Creative, arts and entertainment activities	2.26	0.488	wB	1.06	0.229	wF
94-99	Other Services activities	1.68	0.363	wB	2.24	0.484	wF

Note: wB- Weak Backward, wF- Weak Forward, sF- Strong Forward, sB- Strong Backward.

Table 6. Key sectors (K), Sectors with Strong Forward Linkages (sF), Sectors with Strong Backward Linkages (sB), Sector with Weak Linkages (W)

		CW		Rasmussen		
ISIC	Activities	BL	FL	BL	FL	Results
01	Crop and Animal production, hunting and related service activities	wB	sF	wB	sF	K
02	Forestry and logging	wB	wF	sB	wF	sB
03	Fish and aquaculture	wB	wF	wB	wF	W
05	Mining of Coal and lignite	wB	wF	wB	wF	W
06	Extraction of crude petroleum and natural gas	wB	sF	wB	sF	sF
07	Mining of metal ores	wB	wF	wB	wF	W
08	Other Mining and Quarrying	sB	wF	wB	wF	sB
10	Manufacture of Food Products	sB	sF	wB	sF	K
11	Manufacture of Beverages	sB	wF	wB	wF	sB
12	Manufacture of Tobacco	sB	wF	wB	wF	sB
13	Manufacture of Textiles	sB	sF	sB	sF	K
14	Manufacture of Wearing apparel	sB	wF	wB	wF	sB
15	Manufacture of Leather Footwear	sB	wF	wB	wF	sB
16	Manufacture of wood and wood products	wB	wF	wB	wF	W
17	Manufacture of paper and paper products	wB	wF	wB	wF	W
19	Manufacture of coke and refined petroleum products	sB	sF	wB	wF	K
20+21	Manufacture of chemicals and chemical products and pharmaceutical preparations	sB	sF	wB	wF	K
22	Manufacture of rubber and plastics products	sB	wF	wB	wF	sB
23	Manufacture of other non-metallic mineral products including Cement	sB	wF	wB	wF	sB
24	Manufacture of basic metals	sB	wF	wB	wF	sB
25	Manufacture of fabricated metal products	sB	wF	wB	wF	sB
26+27	Manufacture of electronic and optical products and electrical equipment	sB	wF	wB	wF	sB
29	Manufacture of motor vehicles, trailers and semi-trailers	sB	sF	sB	sF	K
28+30	Manufacture of machinery and equipment	sB	wF	sB	wF	K
31	Manufacture of furniture	sB	sF	sB	sF	K
32	Other Manufacturing	wB	sF	wB	wF	sF
35	Electricity, gas, steam and air conditioning supply	wB	wF	wB	wF	W
36-39	Water collection, waste collection, Remediation, and Sewage	sB	sF	sB	sF	K
41-43	Construction	sB	wF	wB	wF	sB
45	Repair of motor vehicles and motorcycles	sB	wF	wB	wF	sB
46	Wholesale trade	sB	sF	wB	sF	K
47	Retail trade	sB	sF	wB	sF	K
49	Land transport and transport via pipelines	sB	sF	wB	wF	K
50	Water Transport	wB	wF	wB	wF	W
51	Air Transport	sB	wF	wB	wF	sB

Table 6 (cont.). Key sectors (K), Sectors with Strong Forward Linkages (sF), Sectors with Strong Backward Linkages (sB), Sector with Weak Linkages (W)

		CW		Rasmussen		
ISIC	Activities	BL	FL	BL	FL	Results
52	Warehousing and support activities for transportation	wB	sF	wB	wF	sF
53	Postal and courier activities	wB	wF	wB	wF	W
55+56	Accommodation and Food and beverage service activities	wB	wF	wB	wF	W
58+59+60	Publishing activities, Motion picture, video and television programme production, sound recording and broadcasting activities	sB	wF	wB	wF	sB
61	Telecommunications	wB	sF	wB	sF	K
64+65	Financial services, insurance and pension funding	wB	sF	wB	wF	sF
68	Real estate activities	wB	sF	wB	wF	sF
69-75	Professional, scientific and technical activities	wB	sF	wB	wF	sF
77	Administrative and support service activities	wB	sF	wB	wF	sF
84	Public administration	wB	wF	wB	wF	W
85	Education	wB	wF	wB	wF	W
86-88	Human health and social work activities	wB	wF	wB	wF	W
90-93	Creative, arts and entertainment activities	wB	wF	wB	wF	W
94-99	Other Services activities	wB	wF	wB	wF	W

Note: wB- Weak Backward, wF- Weak Forward, sF- Strong Forward, sB- Strong Backward.