Multi Regional Economic Multipliers

Clive Coetzee

This paper constructs a modified multiregional input‑output (MRIO) model to link the five major regional economies of the province of KwaZulu-Natal using the Chenery- Moses model. A survey approach was used to construct the MRIO model. This involved using primary data collected from a specially conducted survey to estimate the final and intermediate trade flows between the five regions. The results show that Richards Bay and Durban had the highest output multipliers. The results also showed that the value of trade of these regions internally (intra trade) was much higher than the trade between them.

Introduction

A regional economy (urban or local economy) is an agglomeration of numerous economic actors and markets packed into a densely populated geographic area (city or town) and with a large number of complex and intimate interrelationships between its own markets and with markets outside its boundaries. Analysis of the macro economic variables of a regional economy requires an approach embodying greater detail of the economic actors.

A regional economic input-output approach, with its capacity for describing detailed transactions among economic units, is especially well suited to the analysis of regional economies. Essentially, input-output is a method of tracing and using information about transactions between buyers and sellers (Hirsch, 1973). Schaffer (1999) argues that a regional input-output model traces the interactions of regional industries with each other, with industries outside the region, and with final demand sectors. Input-Output analysis essentially creates a picture of a regional economy, describing flows to and from industries and institutions.

Hirsch (1973) states that input-output is, at one level, a theoretical approach with a set of assumptions, well defined mathematical properties, and close relation to the general equilibrium models of Walras and Cassel. At another level, the technique can be considered as the empirical implementation of a special sort of general equilibrium analysis in which restrictions on the data available and simplifying assumptions convert the technique to a relatively highly disaggregate economic accounting and forecasting tool.

Bazzazan et al, (2005) states that many different techniques have been introduced. Generally, three main techniques are all the range: survey, semi survey, and non survey based. Each technique highlighted with an advantage; for survey based accuracy with high cost, for non-survey based low cost and less accuracy and semi survey based technique is at the middle of two other techniques: less accuracy and less cost.

This paper gives details on the technique of constructing a regional input-output model for the KwaZulu-Natal (KZN) province, focusing on the five major regional economies. For this purpose, first we explore the economic structure of five regional economies. Second, describes the technique used in the construction of the regional input-output table. The third; supply a brief overview of multi regional input-output models. The forth; analyse the regional model and the multipliers calculated from the model. Finally, the results will be drawn.

Socio-Economic Structure of the Five Regional Economies

The five regional economies which are also the major municipal regions are:

- Durban. It is the economic hub of KwaZulu-Natal and the major import/export center in South Africa.
- Pietermaritzburg. It is the second largest city within KwaZulu-Natal and is the capital city of the province of KwaZulu-Natal.
- Richards Bay. It is the home of manufacturing in the province, boasting two world class aluminium smelters and the world's largest export coal terminal.
- Port Shepstone. It covers an area of approximately 90 km^2 of coastline, comprising of 21 beaches, not surprisingly the premier tourism destination in the South Africa.
- Newcastle. Situated in the northern corner of the province, it is has significant coal deposits and agricultural land.

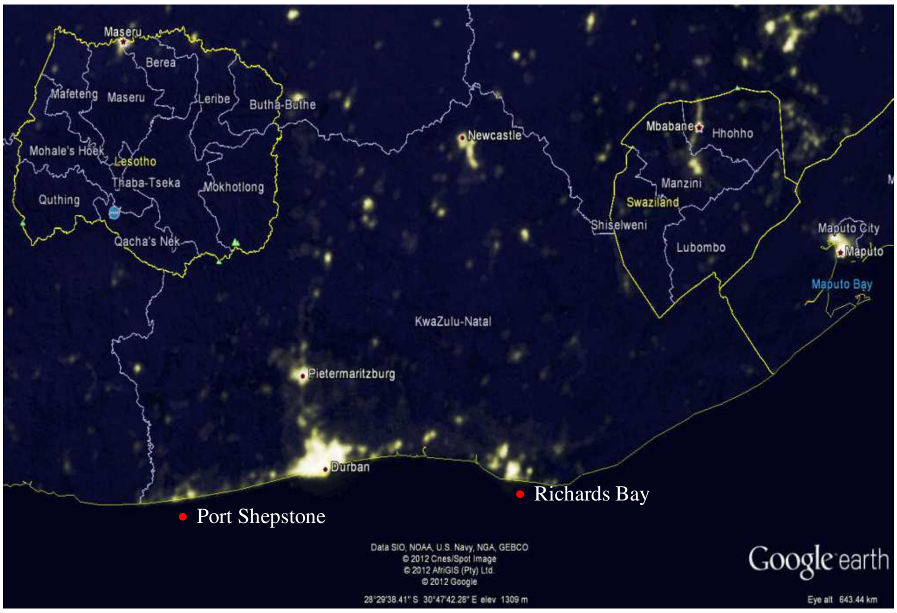
These five regional economies dominate the economic landscape of the province, for example:

- Almost 55 percent of the provincial population resides in the five regions.
- Almost 80 per cent of the provincial GDP is produced in the five regions.
- Personal per capita income is more than double in the five regions compared to the rest of the province.
- Poverty levels are almost half in the five regions compared to the rest of the province.
- The five regions cover only about 8.5 per cent of the total provincial land cover.
- Population density levels are more than 12 times higher in the five regions compared to the rest of the province.
- The five regions accounted for about 93 per cent, 86 per cent and 78 per cent of all new Office & Banking Space, Shopping Space and Industrial & Warehouse Space from 2001 to 2008.

(Global Insight, Stats SA and Own Sources and Calculations)

The below earth night satellite map clearly demonstrates the economic dominance of the five regions in the province (map 1).

Map 1: Satellite Map of the Five Regions



(Google Earth)

The regions differ significantly in terms of their population size as well, especially when compared to Durban (table 1). Coetzee (2015), however, indicates that the size distributions of the five regions have not changed noticeably over the period. This suggests that the relative population distributions for the five regions have stayed fairly constant over the period.

Table 1: Population Size (2002 to 2015)

	Provincial	Durban	Pietermaritzburg	Richards Bay	Newcastle	Port Shepstone
2002	9 098 473	3 066 491	599 779	526 707	301 183	387 994
2003	9 203 777	3 100 874	610 353	532 468	305 195	391 552
2004	9 314 126	3 135 938	621 216	538 570	309 387	395 531
2005	9 430 105	3 171 904	632 419	545 075	313 768	399 950
2006	9 550 057	3 210 688	644 108	551 632	318 266	404 620
2007	9 674 667	3 250 440	656 066	558 369	322 908	409 692
2008	9 803 621	3 291 265	668 326	565 380	327 704	415 158
2009	9 937 725	3 333 336	680 955	572 727	332 684	421 057
2010	10 077 996	3 376 806	694 053	580 529	337 898	427 482
2011	10 223 270	3 422 487	707 714	588 647	343 316	434 373
2012	10 373 800	3 469 797	721 712	596 897	348 882	441 674
2013	10 530 745	3 518 477	736 127	605 553	354 674	449 556
2014	10 694 434	3 568 897	750 992	614 510	360 669	457 915
2015	10 919 077	3 621 022	766 370	623 908	366 915	466 871

(Stats SA, Global Insight, Own Calculations)

These five regions also differ significantly in terms of their economic structure. Table 2 displays the annual average (2002 to 2015) contribution rates for each economic sector for each of the five regions compared to the national and provincial economies. The structural differences are fairly evident, for example Richards Bay and Newcastle are "production" economies whilst Pietermaritzburg and Port Shepstone are "consumer" economies. Durban has a much more diversified economy which is fairly similar to the national economy.

Table 2: Annual Average Contribution Rates (%) (2002 to 2015)

	National	Provincial	Durban	Pietermaritzburg	Richards Bay	Newcastle	Port Shepstone
Agriculture, forestry and fishing	2.44	4.34	1.18	4.25	2.89	2.06	**7.66**
Mining and quarrying	6.87	1.81	0.27	0.43	**8.77**	1.22	1.99
Manufacturing	16.39	21.32	**21.06**	12.81	**39.03**	**31.49**	12.24
Electricity, gas and water	2.09	2.24	2.44	2.77	0.58	2.10	1.69
Construction	2.46	2.34	2.52	2.29	1.93	1.90	4.05
Wholesale & retail trade; hotels & restaurants	12.07	12.43	14.15	11.05	6.00	8.72	**16.67**
Transport, storage and communication	8.37	11.18	**13.05**	10.71	9.77	7.72	9.19
Finance, real estate and business services	18.51	15.63	18.06	**19.07**	9.44	13.37	**18.71**
Personal and General Government Services	19.77	17.70	16.30	**26.69**	9.85	**20.44**	17.04

(Stats SA, Global Insight, Own Calculations)

The Gross Domestic Product (GDP at R'm 2010 constant prices) and economic growth rates of the five the regions has also been fairly varied. Table 3 displays the per annual GDP and average economic growth rate of each of the regions and the national and provincial economies. It seems evident that the differences in total economic output are very big and substantial although the economic growth rate disparities are marginal. It is also interesting to note that the regional economic growth rates have been much more volatile than the national and provincial growth rates (except for Pietermaritzburg and Port Shepstone). Coetzee (2016) indicates that the GDP distributions of the five regions have not changed noticeably over the period.

Table 3: Annual Gross Domestic Product (R'm 2010 constant prices) (2002 to 2015)

	SA	KZN	Durban	Pietermaritzburg	Richards Bay	Newcastle	Port Shepstone
2002	2 093 469	322 651	183 390	25 734	19 857	9 785	9 084
2003	2 157 045	331 504	189 731	26 624	20 544	10 123	9 398
2004	2 251 739	346 179	198 131	27 803	21 453	10 571	9 814
2005	2 366 783	365 775	209 346	29 376	22 667	11 170	10 369

2006	2 491 296	385 398	220 577	30 952	23 884	11 769	10 926
2007	2 624 841	408 910	234 033	32 841	25 341	12 487	11 592
2008	2 708 601	424 640	245 609	33 589	27 805	12 578	11 995
2009	2 666 940	418 879	235 790	35 344	24 206	13 237	11 871
2010	2 748 008	433 846	247 805	35 259	26 787	13 272	12 284
2011	2 838 257	449 826	256 758	36 703	27 738	13 769	12 732
2012	2 901 078	461 604	262 330	38 042	27 879	14 279	13 073
2013	2 968 682	472 217	269 210	38 608	28 931	14 502	13 370
2014	3 017 037	482 953	275 156	39 563	29 513	14 851	13 674
2015	3 055 192	489 208	278 552	40 127	29 801	15 067	13 852
Average	**2.97**	**3.27**	**3.30**	**3.49**	**3.33**	**3.39**	**3.32**
St Dev	**1.91**	**2.00**	**2.67**	**1.92**	**5.73**	**1.96**	**1.92**

(Stats SA, Global Insight, Own Calculations)

Input-Output Approach

An input-output model in its basic form consists of a system of linear equations, in which each equation describes the distribution of an industry's economy. It is constructed from observed data for a specific economic area. The economic activity in the area must be divisible into a number of segments or producing sectors. These inter-industry or inter-sectoral flows are measured for a particular time period and, in monetary terms, in what is known as a transaction table. The main body of the transaction table consists of a collection of industries and sectors and shows the inter-sectoral flows, providing many links between different sectors and industries within the economy. An input-output table is made up of rows and columns; rows representing sectoral output and the columns representing sectoral purchases. The figures entered in each column of the table describe the input structure of the corresponding sector, whereas each row shows what happens to the corresponding output sector (Bazzazan et al, 2005).

An input-output table also consists of final demand and value added sections, as in an economy, there are sales to purchasers who are more external or exogenous to the industrial sectors that constitute the producers in the economy, e.g. households, government, and foreign trade. The demand for these units and the magnitudes of their purchases from each of the industrial sectors are generally determined by considerations that are relatively unrelated to the amount being produced in each of the units. The demand from these external units is generally referred to as final demand. Final demand covers total consumption (private or public), capital formation, and exports. The row sum of intermediate demand and final demand equals the gross value of production. Similarly, the column sums of intermediate demand plus value added also equal the gross values of production of an industry (Bazzazan et al, 2005).

A standard input-output table contains an equal number of rows and columns as displayed in the table below. Tables can measure the monetary terms or physical units of produced goods and services, such as tons of steel, bushels of wheat, or gallons of fuel.

Table 4: Input-Output Coefficient in More General Terms

	Industry 1	Industry 2	Industry 3	Net final demand
Industry 1	a_{11}	a_{12}	a_{13}	Y_1
Industry 2	a_{21}	a_{22}	a_{23}	Y_2
Industry 3	a_{31}	a_{32}	a_{33}	Y_3
Value added	V_1	V_2	V_3	

(United Nations, 1999)

The relationships using the general terms of table 4 can be written as follows:

$$
\begin{aligned}
a_{11} X_1 + a_{12} X_2 + a_{13} X_3 + Y_1 &= X_1 \\
a_{21} X_1 + a_{22} X_2 + a_{23} X_3 + Y_2 &= X_2 \\
a_{31} X_1 + a_{32} X_2 + a_{33} X_3 + Y_3 &= X_3
\end{aligned}
$$

In matrix form, the above equations can be written as follows:

$$
\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} x \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} \bullet \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix} \bullet \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix}
$$

Following the construction of the input-output table, it is possible to derive a second table of input or technical coefficients. The term "technical coefficients", according to Pissarenko (2003), refers to the quantity of inputs required from each industry to produce one monetary term's worth of a given industry's output. Because it represents the entire domain of wealth-producing activities, computation of the technical coefficients are restricted to the processing sector industries only. The coefficients can be denominated in either monetary or physical units. The basic formula for determining coefficients is

$$\mathbf{a_{ij} = X_{ij}/x_j}$$

where:

a_{ij} = the input coefficient of industry i into industry j

X_{ij} = the amount of industry i 's output used by industry j

x_j = the total output from industry j

Using this formula, the coefficient $\mathbf{a_{ij}}$ can be obtained for all the industries in an input-output table. Once a transaction table of direct and indirect coefficients (or a coefficient matrix) has been obtained, several common economic analyses can be performed.

The input-output model can be described with the use of the following discussion and set of equations. Let's assume **X** is the production vector needed to fill both the internal needs and the external demand, thus **D = X −AX.** This means that final demand is equal to total final production minus the production needed by other industries as inputs, where total production **X** is the cumulative product made by each industry whether it is used in production or not. The production needed by other industries, as inputs **AX**, is the total amount of product that is used in production.

The relations between the industries, the technology matrix **A**, are known and so is the demand for each industry **D.** The goal would be to find the total production that will be needed to fill a certain demand. We must therefore solve the equation **D = X − AX for X**. Our initial equation is

$$\mathbf{D = X - AX}$$

Any matrix multiplied by an identity matrix is equal to itself so that **IX = X.** Therefore we can replace **X** with **IX** as in below equation.

$$\mathbf{D = IX - AX}$$

X is then factored out from both terms on the right side of the equation. It is important to factor out the X to the right because if it is factored out to the left, matrix multiplication will break down when multiplying the demand vector **D** on the left side by $\mathbf{(I - A)^{-1}}$

$$\mathbf{D = (I - A)X}$$

In order to solve for X, the left side of both sides of the equation is multiplied by $\mathbf{(I - A)^{-1}}$so that

$$\mathbf{(I - A)^{-1}D = (I - A)^{-1}(I - A)X}$$

Any matrix multiplied by it is inverse is equal to the identity matrix $\mathbf{(I - A)^{-1}(I - A) = I}$. Substituting I for $\mathbf{(I - A)^{-1}(I - A)}$ we get

$$(\mathbf{I} - \mathbf{A})^{-1}\mathbf{D} = \mathbf{IX}$$

Since **IX=X**, as stated before, we substitute **X for IX, $(\mathbf{I} - \mathbf{A})^{-1}\mathbf{D} = \mathbf{X}$**. With a little rearranging, the equation to solve for the total production needed to satisfy an economy with a known demand vector **D** and a known technology matrix **A** can be derived as follows:

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{D}$$

Multi Regional Input-Output Model (MRIO)

There are a number of variations of input-output analysis at the regional level, and input-output studies with a regional orientation can be classified in a number of ways. One major distinction is between interregional (or multiregional) models and regional models. In the former, a single model includes more than one region, while regional models are similar to national models except that they cover a smaller geographic area.

Chenery (1953) and Moses (1955) developed the first version of a MRIO model, which used the following simplification: interregional trade flows are only specified by region of origin and region of destination, being ignored the specific industry (or final consumer) of destination. MRIO analysis allows users to define a large region and capture leaked impacts while maintaining the specificity and individual identities of the direct impact location and each of the linked regions of interest.

The MRIO model, according to Sargento (2009) is based on the notion that when one region increases its production, as a reaction to some exogenous change in its final demand for example, some of the inputs needed to answer the production augment will come from the remaining regions, originating an increase of production in these regions, the so called spillover effects. The remaining regions, in turn, may need to import inputs from other regions (probably including the first region) to use in their own production. These involve the concept of interregional feedback effects: those which are caused by the first region in itself, through the interactions it performs with the remaining regions (Miller, 1998).

The MRIO model therefore is usefull in so far the analysis of interregional feedback effects and the degree to which change originating in one region has capacity to influence activity levels in another region, in turn, will effect activity back in the region of origin.

Let’s assume a five region macro-economic input-output model x1 to x5 so that the direct technical coefficients can be represented by the following block sub-matrix. Technical coefficients reflect the direct effects of change in final demand for a certain commodity/region.

$$
A = \begin{Bmatrix} A11 & A12 & A13 & A14 & A15 \\ A21 & A22 & A23 & A24 & A25 \\ A31 & A32 & A33 & A34 & A35 \\ A41 & A42 & A43 & A44 & A45 \\ A51 & A52 & A53 & A54 & A55 \end{Bmatrix}
$$

where A_{11}, A_{22}, A_{33}, A_{44} and A_{55} are the quadrate matrices (technical coefficients) of direct inputs within regions 1 to 5 (i.e. intra-regional), respectively. The other technical coefficients are the interregional matrices representing direct inputs connections from regions 1 to 5 and from region 5 to region 1 (i.e. inter-regional), respectively. Final demand (Y) and gross output (X) vectors are partitioned in a similar fashion:

$$
X = \begin{Bmatrix} X1 \\ X2 \\ X3 \\ X4 \\ X5 \end{Bmatrix} \text{ and } Y = \begin{Bmatrix} Y1 \\ Y2 \\ Y3 \\ Y4 \\ Y5 \end{Bmatrix}
$$

The Standard Leontief inverse matrix will have following form:

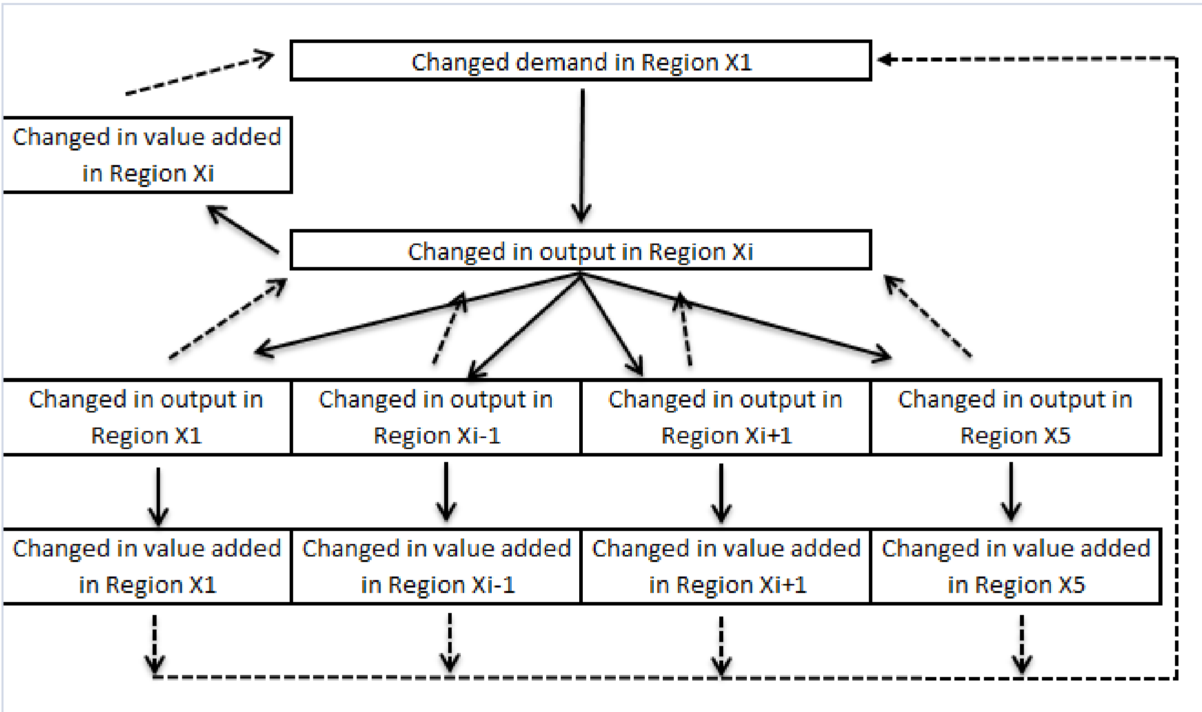
$$
B = (\mathrm{I} - \mathrm{A})^{-1} \begin{Bmatrix} B11 & B12 & B13 & B14 & B15 \\ B21 & B22 & B23 & B24 & B25 \\ B31 & B32 & B33 & B34 & B35 \\ B41 & B42 & B43 & B44 & B45 \\ B51 & B52 & B53 & B54 & B55 \end{Bmatrix}
$$

Assume the finale demand for a good or service in region x_1 increase for whatever reason. Since region x_1 is reliant on itself (intermediate flows from its own firms) and on intermediate flows from firms in regions x_2 to x_4 (at various levels) to meet the increased demand (final demand), region x_1 and regions x_2 to x_4 (domestic exports) increase their production to meet the increase demand in region x_1. The increase in production in regions x_1 to x_5 will be dependent on the level of self sufficiency of region x_1 and the degree of interregional linkages (spill effect) between region x_1 and regions x_2 to x_4.

In order for regions x_1 to x_5 to increase their production they have to buy intermediate goods and services (intra and interregional intermediate flows) from regions x_1 to x_5 (imports for regions x_2 to x_4). The increase in the purchasing of intermediate goods and services in regions x_1 to x_5 (feedback effects) will be dependent on the increase in production in each region, the level of self sufficiency in each region and the degree of interregional linkages between the regions.

To summarize; the MRIO model adds interregional spillovers and interregional feedbacks to the single-region Input-Output model, with the following relation (using the above scenario): feedback^{x1}= spillover $^{x1 \rightarrow x2,\ x3 \text{ and } x4}$ * intra-regional effect $^{x2,\ x3 \text{ and } x4}$ * spillover $^{x2,\ x3 \text{ and } x4 \rightarrow x1}$. The basis MRIO model enables us to calculate the regional and the interregional impacts of any change in exogenous final demand in one consistent framework. The effects quantified by the model, i.e., the inter regional spillover and feedback effects can be depicted as follows:

Figure 1: Spillover and feedback effects in a 5-regions model



Constructing the Multi Regional Input-Output Model

The standard input-output approach as discussed can be used to estimate how changes in one regional economy affect the regional economies linked to it, i.e., to estimate or model inter-regional interdependence. It is therefore possible to construct a regional input-output table on the assumption that the required data is available.

The purpose of a regional input-output table, as stated, is therefore to estimate or model the inter-relationships that exist between different regional economies. It is based on the argument that the regional economies are not closed economies but open economies. There is thus a constant flow of goods and services between the various regional economies so each regional economy buys and sells from each of the other regional economies. The output of any regional economy (for examply, the Pietermaritzburg economy) is needed as an input to many other regional economies, or even for that regional economy itself; therefore the "correct" (i.e., shortage-free as well as surplus-free) level of regional economic output will depend on the input requirements of all the ***n*** regional economies. In turn, the output of the many other regional economies will enter into the Pietermaritzburg economy as inputs, and consequently the "correct' levels of the other regional economies will in turn depend partly upon the input requirements of the Pietermaritzburg economy. This can be demonstrated by the following set of equations:

$$\mathbf{x_1 = \alpha_{11}x_1 + \alpha_{12}x_2 + \alpha_{13}x_3 + \alpha_{14}x_4 + \alpha_{15}x_5 + d_1}$$

$$\mathbf{x_2 = \alpha_{21}x_1 + \alpha_{22}x_2 + \alpha_{23}x_3 + \alpha_{24}x_4 + \alpha_{25}x_5 + d_2}$$

$$\mathbf{x_3 = \alpha_{31}x_1 + \alpha_{32}x_2 + \alpha_{33}x_3 + \alpha_{34}x_4 + \alpha_{35}x_5 + d_3}$$

$$\mathbf{x_4 = \alpha_{41}x_1 + \alpha_{42}x_2 + \alpha_{43}x_3 + \alpha_{44}x_4 + \alpha_{45}x_5 + d_4}$$

$$\mathbf{x_5 = \alpha_{51}x_1 + \alpha_{52}x_2 + \alpha_{53}x_3 + \alpha_{54}x_4 + \alpha_{55}x_5 + d_5}$$

where:

$x_{1 \text{ to } 5}$ is the five regional economies

$\alpha_{1n}x_n$ is the input demand of the five regional economies

d_n is the final demand for its output

After moving all terms that involve the variables x_n to the left of the equal signs, and leaving only the exogenously determined final demands d_n on the right, we can express the "correct" output levels of the *n* regional economy by the following system of *n* linear equations.

$$(1-\alpha_{11})x_1 - \alpha_{12}x_2 - \alpha_{13}x_3 - \alpha_{14}x_4 - \alpha_{15}x_5 = d_1$$

$$-\alpha_{21}x_1 + (1-\alpha_{22})x_2 - \alpha_{23}x_3 - \alpha_{24}x_4 - \alpha_{25}x_5 = d_2$$

$$-\alpha_{31}x_1 - \alpha_{32}x_2 + (1-\alpha_{33})x_3 - \alpha_{34}x_4 - \alpha_{35}x_5 = d_3$$

$$-\alpha_{41}x_1 - \alpha_{42}x_2 - \alpha_{43}x_3 + (1-\alpha_{44})x_4 - \alpha_{45}x_5 = d_4$$

$$-\alpha_{51}x_1 - \alpha_{52}x_2 - \alpha_{53}x_3 - \alpha_{54}x_4 + (1-\alpha_{55})x_5 = d_5$$

This can be written in matrix notation as follows:

$$\begin{bmatrix} (1-\alpha_{11}) & -\alpha_{12} & -\alpha_{13} & -\alpha_{14} & -\alpha_{15} \\ -\alpha_{21} & (1-\alpha_{22}) & -\alpha_{23} & -\alpha_{24} & -\alpha_{25} \\ -\alpha_{31} & -\alpha_{32} & (1-\alpha_{33}) & -\alpha_{34} & -\alpha_{35} \\ -\alpha_{41} & -\alpha_{42} & -\alpha_{43} & (1-\alpha_{44}) & -\alpha_{45} \\ -\alpha_{51} & -\alpha_{52} & -\alpha_{53} & -\alpha_{54} & (1-\alpha_{55}) \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \\ d_3 \\ d_4 \\ d_5 \end{bmatrix}$$

If the 1s in the diagonal of the matrix on the left are ignored, then matrix is simply

$$-A=[-\alpha_{ij}]$$

where:

α_{ij}= input coefficients

The matrix is the sum of the identity matrix I and the matrix –A. Thus the above equation can be written as:

$$(I - A)x=d$$

where:

$(I - A)$=the Leontief matrix

x = regional economy vector

d = final demand vector

The annual regional economic business confidence surveys that have been conducted since 2005 contain a question relating to the proportion of products and services sold by businesses in a particular regional economy to the other regional economies. The questionnaire currently contains around 25 questions, seven more than in 2005. The surveys are conducted through the various local chamber of business and other local business organizations operating in the five economic regions (only three urban centres from 2005 to 2010). The survey is an online anonymous business survey designed specifically to generate data and information on a number of local economic characteristics and trends, and the general level of business confidence in the particular urban centre

The Newcastle respondents, for example, will therefore indicate the proportion of their total sales (exports) to the other four regional economies. The yearly proportions (2011 to 2015) have been averaged in order to minimize the risk of outliers and are displayed in matrix format in the table below (table 5). The totals are not equal to one hundred because it excludes the proportions of the total sales that are sold outside the five regional economies, for example to the rest of the province.

Table 5: Production and Output Matrix

Regional economy of Production					
	Pietermaritzburg	Durban	Richards Bay	Port Shepstone	Newcastle

Regional economy of Residence	Pietermaritzburg	0.444	0.100	0.038	0.033	0.026
	Durban	0.060	0.494	0.093	0.014	0.023
	Richards Bay	0.037	0.059	0.617	0.007	0.048
	Port Shepstone	0.040	0.116	0.018	0.416	0.011
	Newcastle	0.023	0.099	0.014	0.012	0.352
	Total	0.604	0.867	0.779	0.481	0.459

(own calculations)

For the above matrix the matrix I-A is as follows (table 6).

Table 6: I-A Matrix (Sales)

0.556	-0.100	-0.038	-0.033	-0.026
-0.060	0.506	-0.093	-0.014	-0.023
-0.037	-0.059	0.383	-0.007	-0.048
-0.040	-0.116	-0.018	0.584	-0.011
-0.023	-0.099	-0.014	-0.012	0.648

(own calculations)

The inverse of the I-A matrix is indicated in the table below (table 7). These values are also known as multipliers. This means for example that when the demand for goods and services in the Pietermaritzburg economy increases by R1, the production of goods and services in Pietermaritzburg, Durban, Richards Bay, Newcastle and Port Shepstone economies will increase on average by R1.88, R0.28, R0.24, R0.20 and R0.12, respectively (spillover effects).

Table 7: Regional Economic Multipliers (Sales)

		Pietermaritzburg	Durban	Richards Bay	Port Shepstone	Newcastle
Inverse matrix	Pietermaritzburg	**1.881**	**0.457**	**0.306**	**0.122**	**0.115**
	Durban	**0.279**	**2.138**	**0.553**	**0.074**	**0.129**
	Richards Bay	**0.243**	**0.425**	**2.746**	**0.060**	**0.229**
	Port Shepstone	**0.194**	**0.475**	**0.216**	**1.737**	**0.069**
	Newcastle	**0.119**	**0.362**	**0.160**	**0.050**	**1.574**

(own calculations)

An Elementary Example

Let's assume final demand in the Pietermaritzburg economy increases with a R100 for whatever reason with no change in final demand in the other 4 regional economies. Applying the regional multipliers (interdependence coefficients) (table 7) provides the estimates of both direct and indirect effects (in cents) of changes in final demands for products and services in the Pietermaritzburg economy. The new level of output in each region is displayed in the table below. The cumulative production (intra and interregional flow of final goods and services) that has taken place in the five regions combined to meet the increase in final demand is calculated at **R271.65**.

Table 8: Output Change in cents (multiplier effect)

	Output
Pietermaritzburg	**188.119**
Durban	**27.914**
Richards Bay	**24.312**
Port Shepstone	**19.413**
Newcastle	**11.889**
Total	**271.647**

Using the technical coefficients (table 5), the intra and interregional flows (value of the deliveries/sales) are calculated as shown in below table. The rows contain the output of a region, i.e. the value of the deliveries/sales of a region to the different regions. E.g., Pietermaritzburg delivers goods and services with a value of R83 to Pietermaritzburg, goods and services with a value of R2.87 to Durban, etc and R100 of final demand. Value of total production of Pietermaritzburg is R188.12.

Table 9: Intra and Interregional Flows in Deliveries/Sales (R)

	Pietermaritz burg	Durban	Richards Bay	Port Shepstone	Newcastle	Final Demand	Final Output
Pietermaritzburg	**83.478**	**2.784**	**0.918**	**0.636**	**0.303**	**100**	**188.119**
Durban	**11.334**	**13.790**	**2.255**	**0.262**	**0.273**	**0**	**27.914**
Richards Bay	**6.984**	**1.636**	**14.991**	**0.131**	**0.569**	**0**	**24.312**
Port Shepstone	**7.556**	**3.233**	**0.425**	**8.069**	**0.129**	**0**	**19.413**

Newcastle	**4.350**	**2.767**	**0.348**	**0.237**	**4.186**	**0**	**11.889**
Primary Inputs	**74.417**	**3.703**	**5.374**	**10.078**	**6.428**	**-**	**100.000**
Total Inputs	**188.119**	**27.914**	**24.312**	**19.413**	**11.889**	**-**	**271.647**

For each region to increase their production to the new total output levels as indicated above each region has to buy intermediate goods and services (raw materials and semi-finished) from itself and from the other regions (columns). For example for a production of R188.12 Pietermaritzburg spends R83.48 in Pietermaritzburg, R11.33 in Durban etc and the primary costs (capital and labour) are R74.42. The total value of intermediate inputs purchased/spend for Pietermaritzburg is R113.70.

The table below displays the comparative results of a R100 increase in final demand in each of the regions individually (ceteris paribus). The cumulative effect (total production) is the highest when final demand increase in Richards Bay and the lowest when final demand increases in Port Shepstone.

Table 10: Cumulative Impact of a R100 increase in Final Demand per region (R)

	Pietermaritzburg	Durban	Richards Bay	Port Shepstone	Newcastle
Pietermaritzburg	**188.119**	**45.666**	**30.557**	**12.191**	**11.487**
Durban	**27.914**	**213.759**	**55.284**	**7.411**	**12.896**
Richards Bay	**24.312**	**42.462**	**274.636**	**5.993**	**22.859**
Port Shepstone	**19.413**	**47.455**	**21.582**	**173.714**	**6.948**
Newcastle	**11.889**	**36.168**	**16.028**	**4.973**	**157.370**
Primary Inputs	**100.000**	**100.000**	**100.000**	**100.000**	**100.000**
Total Inputs	**271.647**	**385.510**	**398.086**	**204.282**	**211.561**

The table below displays some further statistics wrt the total impact derived from a R100 increase in final demand in each of the regions individually (ceteris paribus). It shows that an increase in final demand in Durban has the largest impact on the remaining four regions collectively where as an increase in final demand in Port Shepstone has the smallest impact on the remaining four regions collectively (in R value terms).

Table 11: Domestic vs. External Impact (R)

	Pietermaritzburg	Durban	Richards Bay	Port Shepstone	Newcastle
Multipliers	2.716	3.855	3.981	2.043	2.116
Final Demand	100.000	100.000	100.000	100.000	100.000
Total Impact	271.647	385.510	398.086	204.282	211.561
Domestic Impact	188.119	213.759	274.636	173.714	157.370
External Impact	83.528	171.751	123.451	30.568	54.191

Table 12 displays the domestic and regional trade flows, value added and total domestic production wrt the total impact derived from a R100 increase in final demand in each of the regions individually (ceteris paribus). Durban export and import the most whilst Port Shepstone export and imports the least. Value added in the most in Port Shepstone whilst being the least in Durban.

Table 12: Domestic and Regional Trade Flows (R)

	Pietermaritzburg	Durban	Richards Bay	Port Shepstone	Newcastle
Domestic Sales	83.478	105.597	169.347	72.207	55.414
Exports	4.641	8.162	5.288	1.507	1.956
Total Sales	88.119	113.759	174.636	73.714	57.370
Domestic Purchases	83.478	105.597	169.347	72.207	55.414
Imports	30.224	79.803	44.580	11.326	16.871
Total Purchases	113.702	185.401	213.927	83.533	127.699
Value Added	74.417	28.359	60.708	90.181	85.085
Total Production	188.119	213.759	274.636	173.714	157.370

The table below displays the percentage intra vs. interregional flows for each of the five regions. It shows that Durban is the most “open” regional economy whilst Port Shepstone in the least.

Table 13: Intra vs. Interregional Flows (%)

	Pietermaritzburg	Durban	Richards Bay	Port Shepstone	Newcastle
Intra Regional Flows	**70.539**	**54.554**	**77.251**	**84.909**	**74.640**
Interregional Flows	**29.461**	**45.446**	**22.749**	**15.091**	**25.360**

Table 14 displays each of the five regions major trading partners in terms of sales and purchases.

Table 14: Major Trading Partners

	Pietermaritzburg	Durban	Richards Bay	Port Shepstone	Newcastle
Major Sales Partner	**Durban**	**Richards Bay**	**Durban**	**Durban**	**Durban**
Major Purchases Partner	**Durban**	**Port Shepstone**	**Durban**	**Pietermaritzburg**	**Richards Bay**

Summary and Conclusions

The main objective of the well known input-output model, developed by Leontief in the late 1930s, is to study the interdependence among the different sectors in any economy. This tool holds upon a very simple, yet essential notion, according to which the output is obtained through the consumption of production factors (inputs) which can be, in their turn, the output of other industries. The original applications of the input-output model were made at a nation-wide level. However, the interest in extending the application of the same framework to spatial units different from the country (usually, sub-national regions) led to some modifications in the national model, originating a set of regional input-output models.

This paper has developed a modified MRIO model for the province of KwaZulu-Natal using the Chenery-Moses model. A diacritical feature of this study is that, unlike most other studies that construct IO models for a single country, the MRIO model was developed to link the five major regional economies in the province. A survey approach was used to construct the MRIO model. This essentially involved using primary data collected from a specially conducted survey to develop the MRIO model.

As can be observed above, an MRIO model can be used for various applications such as multiplier, linkage, and impact analyses as well as estimation of interregional spillover and feedback effects.

The multiplier analysis found that the Richard Bay economy had the highest output multipliers whilst Port Shepstone had the smallest. The analysis of the economic relationship between the five regions found that the value of intra-trade of these five with the regions was much higher (in varying degrees) than the value of the inter-regional trade.

Durban seems to have a fairly open economy trading significantly with the other four regions followed by Pietermaritzburg and Richards Bay. Port Shepstone and Newcastle seems to be fairly closed economies trading predominantly internally. This possible explains the reason why the multiplier analysis found that the Port Shepstone and Newcastle economies had the smallest output multipliers.

The results suggest that there is indeed some flow of final and intermediate goods and services between the five regions. Consequently, the estimated interregional spillover and feedback effects seem to be rather negligible.

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