INTRODUCTION

If one considers the economic concerns that dominate business planning, it is apparent that short term prospects are more important than the long term economic environment.

This is practical since managers are primarily concerned with short term prospects such as a down turn in fortunes from one year to the next. Given this concern, it is more important for managers to examine short term changes in the business cycles rather than long term fluctuations in the economic environment. This is particularly so in a company which is seen to be robust, i.e. the company is resilient to changes in the business environment and will remain 'satisfying' under any conceivable scenario.

After the Second World War, the South African economy was seen as a surprise free scenario which was characterised by relevant cyclical movements around an economic reference line which was expected to shift upward at an average compound rate of 4-5% p.a.

The economy gave a vision of growing prosperity and business planning was geared to placing the company in a position to exploit this growing prosperity.

In reality a study of the economy from 1975 to 1983 has revealed a real growth rate of 2.5% which was less than even the 'worst case' scenario predicted earlier.

From 1982 - 1985, a negative real growth rate has been measured and this coupled with double digit inflation and rapidly declining value of exchange rate of the rand, have seriously undermined this vision of underlying stability.

Taking this into account, it is understandable that a company should be interested in the possible changes of direction in the economy. The management of a company should have a feel for sectorial inter-relationships within the economy and consequently for the possible directions of economic development under different assumptions of growth and socioeconomic change.

The specific planning needs which form the reason for the analyses required are firstly, the need to develop a robust framework for the analysis of possible structural shifts, and secondly, to operationalise this framework in a formal computer model that can form part of the planning and decision-making process within a company.

The method chosen for this was the Input/Output technique which is a description of inter-industry flows of goods and services in a particular year. This method has some limitations such as the assumption of constant relative prices; constant technologies and linear production functions. These tend to limit its use as a comparative static or dynamic analysis. The technique coupled with others such as sensitivity analysis and by introducing long term trend data trends in the national economy.
I/O TABLE APPLICATIONS

The purpose of an input/output model is to forecast the industrial implications of changes in the overall national economy. Given forecasts of broad components of GNP such as personal consumption expenditures, investment, exports imports etc., the I/O model makes predictions of output originating in different industries.

The model can be used to predict the increase in total consumer expenditures or durable goods as a consequence of a tax cut. The model however, is not capable of forecasting the resultant expansion in the output of particular consumer durable goods.

The most important question the model will answer is by how much the Given Product Originating (GPO), (which is the sum of wages, salaries, profits etc.,) increase in industries producing consumer durables which are directly affected by increase in demand for consumer durables and in industries which are indirectly affected such as electrical utilities.

The analysis of impact of a change in consumer spending is but one of the changes in the economy dealt with by the I/O model. The model also enables the assessment of change in industrial composition of total output of the economy as a consequence of changes in various other variables such as government spending, exports or demographic structure of the population.

Some calculations which can be carried out using the tables are:

1) Effect on output of industry j due to the final demand for sector i.
2) Attributing output of industry j to specific components of final demand (e.g. exports of sector i).
3) Evaluation of sensitivity of specific industrial products to final demand structure.
4) Effect of exchange rate, labour costs or price shifts in other sectors on product cost of sector j.
5) Into sectorial comparisons of requirements of factors of production such as labour skills, capital and resource.
6) Sensitivity and banking analysis of industries with respect to the above issues.
Every firm can be examined from two points of view, firstly, as a producer of the output it sells to other firms and to the final users of its product and secondly, as a user of the inputs it buys from the firms and of primary factors of production it purchases (labour, capital etc.).

Firms may be grouped into industries, which still buy in one range of markets and sells in another and so input/output tables show the dual market relationships among all industries in the economy.

A simple example is shown in Fig (1). This example assumes only 3 industries i.e. agriculture, manufacturing and services which are producers and 4 industries which are users i.e. households, investors, government and foreign countries.

FIGURE 1

<table>
<thead>
<tr>
<th>Intermediate Demand</th>
<th>Total Demand (Final Users)</th>
<th>Total Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BUYING</td>
<td></td>
</tr>
<tr>
<td>AGR (1)</td>
<td>MFG (2)</td>
<td>SVCS (3)</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
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<tr>
<td>SELLING</td>
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<td>INDUSTRIES:</td>
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<td>AGR (1)</td>
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<td>MFG (2)</td>
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<td>SVCS (3)</td>
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<tr>
<td>VALUE ADDED (Va)</td>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
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<tr>
<td>Wages</td>
<td>20</td>
<td>50</td>
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<tr>
<td>Profit</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Other</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Total Va</td>
<td>70</td>
<td>90</td>
</tr>
<tr>
<td>Cost of Materials</td>
<td>+ Va</td>
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</tr>
<tr>
<td></td>
<td>100</td>
<td>200</td>
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<tr>
<td>TOTAL Va:</td>
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<td>245</td>
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<tr>
<td></td>
<td>-</td>
<td>GNP</td>
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<td>TOTAL FINAL DEMAND:</td>
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<td>100</td>
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<td>245</td>
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<td>GNP</td>
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</tbody>
</table>

In reality, the model contains far more (see Appendix 1).
Fig (1) shows the flows of goods and services among different industries as intermediate demand.

E.g. Industry (2) sell 30 output to Industry (1), it uses 10 of its own product and sells 20 to Industry (3).

Final demand transactions show sales of producing industries to final users.

E.g. Industry (2) sell 10 to consumers, 40 to investors, 60 to government and 30 to foreign countries.

Thus for industry (2):

Intermediate demand = 60  
Total final demand = 140

By adding these together we get a basic input/output identity. It is called the row identity and gives the total value of sales for an industry.

Total output = intermediate demand + final demand.

The final demand identities show the product distribution of the GNP components. If we sum the final user column we get the total output sold by all industries to households for consumption. The sum of the second final demand column is the total value of the machinery and other investment goods sold by all the industries to business firms. The total amount of goods and services sold to government by all the industries is obtained by summing down the column G and the column Ex.

In the example summing the totals of the four final demand categories gives 245 which is the GNP of the economy. The components are referred to as GNP components.

To evaluate the cost structure of industries, the following method is adopted. The value of materials purchased is read down the column. The primary factor payments by industry constitute value added.

If the materials purchased are added to the value added we will get the total output of Industry 2.

\[ \text{Output} = \text{Cost of Materials} + \text{Value Added} \]
\[ = 20 + 10 + 80 + 90 \]
\[ = 200 \]

If the value added in all industries is totaled, we get GNP, the total value of goods and services produced by the economy.

In the example:

\[ 70 + 90 + 85 = 245 \]
BASIC PARAMETERS OF INPUT/OUTPUT MODELS

The basic parameters are the input/output coefficients and the final demand coefficients. These are ratios taken from a base I/O table.

While actual value fluctuates from year to year, the coefficients are more or less stable. This temporal stability is used in I/O forecasting methods.

The coefficient $A_{ij}$ shows the value needed from industry $i$ to industry $j$ to produce a unit value of $j$'s output.

The coefficient is estimated as a ratio of the value of the total output of the industry at a point of time:

$$A_{ij} = \frac{X_{ij}}{X_j}$$

where:

- $X_{ij}$ = Sale of $i$th industry products to $j$th Industry.
- $X_j$ = Total output of industry $j$.

From Fig (1) nine coefficients can be constructed:

$$a_{11} = 0.0 \div 100 = 0.0 \quad a_{12} = 0.0 \div 200 = 0.1 \quad a_{13} = 0.0 \div 150 = 0.3$$

This can be written as a matrix:

$$A = \begin{bmatrix} 0.0 & 0.1 & 0.3 \\ 0.3 & 0.05 & 0.13 \\ 0.0 & 0.4 & 0.0 \end{bmatrix}$$

This shows for example, $a_{12}$ is the value of agricultural products directly needed to produce a unit worth of manufacturing output.

The two identity for a particular industry in matrix notation is:

$$X = AX + F$$

where:

$$X = (X_1, X_2, \ldots, X_N)' \quad & F = (F_1, F_2, \ldots, F_n)'$$
The second set of coefficients which are crucial are the final demand coefficients (Bridge coefficients). These show the product composition of various categories of aggregate expenditure. The coefficient denoted by $H_{ik}$ shows the $i$th industry's products in the $k$th GNP component:

$$H_{ik} = \frac{F_{ik}}{E_k}$$

where:

- $F_{ik}$ = value of $i$th industry product going into the $k$th final demand category ($k$th GNP component)
- $E_k$ = total value of $k$th category of final demand

In Fig (1) total household expenditure is 100. Out of this 30 units and spent on goods produced by industry 1. Similarly, total investment spending by all economic units is 40 units. None of this is spent on goods produced by industry 1 because the agricultural sector does not produce investment goods,

therefore,

$$h_{11} = 30 \div 100$$
$$= 0.3$$

$$h_{12} = 0 \div 40$$
$$= 0.0$$

$$h_{34} = 5 \div 37$$
$$= 0.135$$

In matrix form:

$$H = \begin{bmatrix}
0.3 & 0.0 & 0.044 & 0.054 \\
0.1 & 1.0 & 0.882 & 0.811 \\
0.6 & 0.0 & 0.074 & 0.135
\end{bmatrix}$$

If the matrices $A$ and $H$ are reasonably stable over time a base year may be constructed to make forecasts. However, technology and other factors cause changes in $A$ and $H$ coefficients from year to year and these must be taken into consideration when forecasting.

$$F = HE$$

where:

$$F = (F_1,F_2,F_3)$$
$$E = (E_1,E_2,E_3,E_4)$$

$$F = \begin{bmatrix}
0.3 & 0.0 & 0.044 & 0.054 \\
0.1 & 1.0 & 0.882 & 0.811 \\
0.6 & 0.0 & 0.074 & 0.135
\end{bmatrix}$$
This calculation implies:

* of the 200 units of total expenditure by households for consumption 30% will be purchased from industry 1 (agriculture).
* of the 60 units of investment expenditures by the entire economy nothing will be spent on agriculture.
* 4.4% of government expenditure will be on products produced by agriculture.

The total demand for products of industry 1 will be:

\[ F_1 = (0.3 \times 200) + (0.0 \times 60) + (0.044 \times 120) \]
\[ + (0.054 \times 100) \]
\[ = 70.7 \]

For industry 2:

\[ F_2 = (0.1 \times 200) + (1.0 \times 60) + (0.882 \times 120) \]
\[ + (0.811 \times 100) \]
\[ = 267.00 \]

and industry 3:

\[ F_3 = (0.6 \times 200) + (0.0 \times 60) + (0.074 \times 120) \]
\[ + (0.135 \times 100) \]
\[ = 142.3 \]

Next, the outputs needed directly and indirectly from each of the three industries to support the final demands are estimated.

The total (direct and indirect) output requirements from industries 1, 2 and 3 are \( X_1, X_2 \) & \( X_3 \). To produce \( X_1, X_2 \) and \( X_3 \) units of output by industries 1, 2 and 3, the intermediate demand requirements will be:

\[
\begin{bmatrix}
0.0 & 0.1 & 0.3 & X_1 \\
0.3 & 0.05 & 0.13 & X_2 \\
0.0 & 0.4 & 0.0 & X_3 \end{bmatrix}
\]

The intermediate demand for products of industry 1 consist of flows to itself, flows to industry 2 and flows to industry 3. According to the above equation:

a) to produce \( X_1 \) of output, industry 1 needs \( a_{11} \times X_1 = (0.0 \times X_1) \) units worth of its own products.

b) to produce \( X_2 \) units of output industry 2 requires \( a_{12} \times X_2 = (0.1 \times X_2) \) worth of products from industry 1.

c) to produce \( X_3 \) units of output industry 3 needs \( a_{13} \times X_3 = (0.3 \times X_3) \) units worth of output from industry 1.
From the A matrix, we know all = 0, a12 = 0.1 and a13 = 0.3 and so the intermediate demand for industry 1 is:

0.0 x X1 + 0.1 x X2 + 0.3 x X3

the intermediate demands for the products of industries 2 and 3 are:

0.3 x X1 + 0.05 x X2 + 0.13 x X3
and

0.0 x X1 + 0.4 x X2 + 0.0 x X3

The total output requirement is obtained by intermediate demand and final demand.

\[ X = AX + F \]

where AX is a vector of intermediate demands and F is a vector of final demands:

\[
\begin{bmatrix}
0.0 & 0.1 & 0.3 \\
0.3 & 0.05 & 0.13 \\
0.0 & 0.4 & 0.0
\end{bmatrix}
\]

\[
\begin{bmatrix}
X1 \\
X2 \\
X3
\end{bmatrix}
\]

\[
\begin{bmatrix}
F1 \\
F2 \\
F3
\end{bmatrix}
\]

Rewriting this we get:

\[(I - A)X = F\]

I being the identity matrix.

Expanding the equation,

\[
\begin{bmatrix}
1.0 & -0.0 & -0.1 & -0.3 \\
-0.3 & 1.0 & -0.05 & -0.13 \\
-0.0 & -0.4 & 1.0 & -0.0
\end{bmatrix}
\]

\[
\begin{bmatrix}
X1 \\
X2 \\
X3
\end{bmatrix} = \begin{bmatrix}
F1 \\
F2 \\
F3
\end{bmatrix}
\]

Since we know F1 = 70.7, F2 = 267.0 and F3 = 142.3 we can substitute and solve to get:

X1 = 198.1, X2 = 385.2 and X3 = 296.4

In matrix notation, the solution is:

\[ X = (I - A)^{-1} F \]

(I - A)^{-1} is total requirements matrix. The ith, jth element of this matrix represents the amount of output of industry i required directly and indirectly to satisfy one units worth of final demand for industry j.

The total requirements are implicitly calculated as the sum of direct and all indirect effects and can be seen from the power series expansion of the (I - A)^{-1} matrix:

\[ X = (I - A)^{-1} F = F + AF + A^2F + A^3F + \ldots + AhF + \ldots \]

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THE SOUTH AFRICAN INPUT/OUTPUT TABLE

The South African table as used in Gencor, is shown in Appendix A, along with a table of the descriptions of all sectors. This table contains 92 industrial sectors. The remainder of the sectors shown are accumulations of the industrial sectors, with the 103 column and row being totals of the entire table. The 103rd row being the GNP components with GNP indicated in position 103,103.

SAS PROGRAMS TO PERFORM ANALYSES

In the case at hand, PROC MATRIX under SAS Ver 5.16 was used to perform all calculations. It is advisable however, that new users make use of SAS/IML due to the imminent withdrawal of Proc Matrix in SAS Ver 6.

The data can be read from a file or read instream. In our case, the data was read from a tape supplied by the Central Statistics Services. The tape was read into a file and then written in a SAS data set using the following code:

```
data _Null_;  
infile table;  
input;  
put infile_;  
output tab.table;  
run;
```

This creates a SAS dataset referenced by the libref tab with a member name table.

NB: Library creation is dependant on operating system.

To read the data into proc matrix, the following is used:

```
proc matrix;  
fetch A data = tab.table.  
```

Intermediate demand is calculated by:

```
proc matrix;  
fetch A data = tab.table  
B = (+,1:93);  
output B out = tab.Bout;  
proc print data = tab.Bout;  
run;
```

Final demand is given by:

```
proc matrix;  
fetch A data = tab.tab;  
C = (+,94:102);  
output C out = tab.Cout;  
proc print data = tab.Cout;  
run;
```
Total output is given by adding intermediate demand and final demand:

```
Proc Matrix;
fetch A data = tab.table
B = A (+,1:93);
C = A (+:94:102);
D = B + C;

OR
D = A (+,1:102);
output D out = tab.Dout;
proc print data = tab.Dout;
run;
```

To calculate GNP the following is used:

```
proc matrix/
fetch A data = tab.table;
E = A (94:102,+);
F = E (1,+);
output F out = tab.Fout;
proc print data = tab.Fout;
run;
```

The 103rd column, which is a total, is generally concatenated to the matrix.

```
proc matrix;
fetch A data = tab.table;
O = A(+,1:102);
G = A//d;
output G out = Gout;
proc print data = Gout;
run;
```

To calculate the output of an industry:

```
proc matrix;
fetch A data = tab.table;
H = A (n,+);
J = A (n,+)
K = H + J;
output K out = tab.Kout;
proc print data = tab.Kout;
run;
```
To calculate I/O coefficient and create the A Matrix:

```
proc matrix;
fetch A data = tab.table;
L = A (1:102,+);
M = L/L;
N = M/M;
O = N/N/N/N;
P = O/O/N/N;
Q = A#P;
output Q out = tab.Qout;
proc print data = tab.Qout;
run;
```

To calculate final demand co-efficients and create the H Matrix:

```
proc matrix;
fetch A data = tab.table;
R = A (94:102,+);
S = A (94:102K);
T = R/R;
U = T/T;
V = U/U/U/U;
W = V/V/V/V;
X = S#W;
output X out = tab.Xout;
proc print data = tab.Xout;
run;
```

To compute industry distribution of final demand aggregates:

```
data tab.input;
input, Coll;
cards;
200
   60
   ;
proc matrix;
fetch A data = tab.table;
fetch B data = tab.input;
Al = B#B;
output Al out = Alout;
proc print data = Alout;
run;
```

If INL is used the Repeat command may be used instead of vertical concatenation to build the 103 x 103 totals matrix.
To estimate the output needed directly and indirectly from each industry to support the final demands calculated above:

```sas
proc matrix;
  fetch A data = tab.Qout;
  G = (+,94:102);
  X1 = INV (I-A);
  X2 = X1*D
output X2 out = tab.X2out;
proc print data = tab.X2out;
run;
```

To calculate the total requirement matrix (I-A):

```sas
proc matrix;
  fetch A data = tab.table;
  Y = INV (I-A)'
output Y data = tab.Yout;
proc print data = tab.Yout;
run;
```

**CONCLUSION**

Despite the ease of use of the SAS System and the relative simplicity of the program involved, the amount of economic scenario that can be deduced from the I/O Tables provide a valuable planning tool for Management.

The results obtained were able to provide an economic background divorced from the usual business cycle analyses and when the two were combined, a more accurate forecast was produced. This will enable a cross industry company, to plan in cases of all scenarios which can improve the company’s resilience to structural changes in the economy.
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INPUT/OUTPUT TABLES

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SAS User Guide IML
SAS User Guide STATISTICS
SAS Institute - Cary, North Carolina USA
TABLE 1 - INPUT-OUTPUT TABLE AT BASIC VALUES, 1985 (R-MILLION)

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>SECTOR01</th>
<th>SECTOR02</th>
<th>SECTOR03</th>
<th>SECTOR04</th>
<th>SECTOR05</th>
<th>SECTOR06</th>
<th>SECTOR07</th>
<th>SECTOR08</th>
<th>SECTOR09</th>
<th>SECTOR10</th>
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<tbody>
<tr>
<td>1</td>
<td>823.1</td>
<td>8.95</td>
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<td>4.51</td>
<td>213.30</td>
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