International Journal of Economics and Finance
www.ccsenet.org/journal.html
Vol. 1, No. 2
August 2009

Assessing Economic Connectedness Degree of the Malaysian Economy: Input-Output Model Approach

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Abstract
Economic connectedness can be defined as the degree of internal connectedness of interdependence between the sectors of an economy. In input-output models intersectoral connectedness is a crucial feature of analysis, and there are many different methods of measuring it. These measures are believed to be important structural indicators, helpful in model estimation. Also, such measures could be analytical useful, along with the input-output models themselves, as descriptions of the nature of the modeled economies, as aids in model estimation, and perhaps as indication of the level of economic development. However, they allow for a summary description and comparative analysis of various linear flow systems. Most of the measures, however, have important drawbacks to be used as a good indicator of economic connectedness, because they were not explicitly made with this purpose in mind. In this paper, I present, discuss, compare and interpretation empirically different indexes of economic connectedness as sectoral connectedness, using a set of four empirical models for the Malaysian economy. The results suggest that mean intermediate coefficient total per sector, % intermediate transaction and % nonzero coefficients are the most generally useful interconnectedness measures for Malaysian Economy.
Keywords: Input-output Model, Intersectoral, Connectedness, Interrelatedness, diversification.

1. Introduction:

Structural analysis is concerned with the qualitative properties of input-output tables, especially the properties of the technical input-output matrix. From the technical matrix of an economy we can see the extent of technical interdependence among sectors. Moreover, by comparing different tables covering different time periods, we can find whether inter-industrial dependence has been intensified or not. So it should mention here the following. If transactions are spread all over the matrix, interdependence is high and the interaction effect large. If transactions are bunched, then interdependence is low and localized, leading to a better approach by partial models of input-output, or otherwise, rather than by general input-output models (GHOSH and SARKAR, 1970; p. 136).

The researcher shall discuss techniques for analyzing the productive structure of the Malaysian economy. In an input-output table, where the position of each industry is arbitrarily assigned, we see figure of different magnitude, including blanks, scattered all over the table. In an economy, however, not every industry is related to all other industries, while some do business only with a few other industries. In other words, changes in some industries will yield greater repercussion effect than change in other. From the multiplier analysis of the economy, it is necessary to give attention to those industries which are likely to extent an important influence on the economy, so that approach measures may be taken in advance to divert undesirable economic fluctuations.

From the technical input-output matrix we can see the direct connection of each industry with the others. However, to decide how important an industry is an economy, it is not enough that we look only at the number of industries directly connected with this industry. An industry may directly sell to or buy from only a few industries, but its customers and suppliers may be connected with a good many other industries. This industry may thus have a profound influence on the economy through its indirect relations with other industries. Therefore, it is essential that we consider all direct and indirect relations of each industry with other industries when we try to decide how important it is. These methods can be associated with any input-output table for defining interrelatedness functions which have economic interpretations. Interrelatedness is also associated with diversification in a simple way, as we will discuss latter. It is empirically possible to examine the way in which interrelatedness has changed over time, and to make predictions about hypotheses such as technological convergence, which have so far been difficult to subject to empirical analysis (YAN and AMES, 1965; p.299). Thus an interrelatedness function would be a useful measure in a number of economic contexts.

The study of economic connectedness in an input-output framework has been an interesting subject for economic analysis and policy making purposes (see e.g., ROBINSON and MARKANDYA 1973, SONIS et al 1998 and DRIDI and HEWINGS 2002). For example, in a more complex economy the effects of (global) policy measures tend to be easily and rapidly propagated and more evenly distributed among sectors, and the same goes for unexpected (desirable or undesirable) shocks of any nature (see, eg., SONIS et al 1995, DIETZENBACHER and LOS 2002, STEINBACK

2004 and OKUYAMA 2007).

The subsequent six sections of this paper are structured as follows. Section 2 discusses the problem and objectives of this paper. Section 3 discusses the theory and literature reviews of measuring interrelatedness. Section 4 deals with the application of these methods to the Malaysian economy. Section 5 examines performance of these measures. Section 5 shows some policy implications. Section 6 presents some conclusions and further studies.

2. The problem and Objectives:

During the past three decades, the Malaysian planners have implemented a series of planning horizon, ranging from short to long-term development plans. Subsequently, updated and adequate data would be required for monitoring the progress and performance towards achieving the planned targets.

The planners aim for the period 1998-2010 sets strategic directions for economic development to the year 2010. This policy has been formulated to ensure that the integration role in national development is sustained and enhanced in the light of new and emerging challenges facing economic development.

Towards this end, the planners will focus on new approaches to increase productivity and competitiveness, deepen linkages with other sectors, venture into new frontier areas as well as conserve and utilize natural resources on a sustainable basis. The policy aims to set in place the enabling and supportive measures as well as a conducive environment to promote growth in the economy. The policies and strategies formulated will continue to emphasise productivity and market driven growth (Ministry of Agriculture and Agro-Based Industry, 2006).

An approach employed by policy makers to project, plan and make decision on national development programs is to use an input-output model. Input-Output analysis has become an increasingly popular means for analyzing economic structures and assisting local economic development decision making. Input-output models provide a variety of useful information. It is a descriptive tool which describes the existing structure of a economy; it provides information on individual economic sectors, the linkages between them and how they co-vary. It also shows the relative importance of individual sectors conditions. Input-Output analyses describe the economic transactions pertaining to the economic activity that occurred within specified reference periods.

In Malaysia, as in most natural resources developing countries, the availability of foreign exchange generated by the rapidly growing export of oil and gas, rubber and Palm oil has been of great importance to the process of economic development. The aim of Malaysia development policy has been, primarily, to invest in the commodities sectors. The rational behind this policy was to build a solid base for the Malaysia economy, by using the oil and gas, rubber and Palm oil revenues to support the establishment of large scale enterprises, which could produce intermediate products at competitive prices for the other industries in the economy; this would thus aid the integration of the national economy. Secondary aims were to assist in income redistribution, import substitution, export growth and agricultural modernization.

Unfortunately, such a policy of inter-sectoral imbalance between economic sectors has lead to a poorly integrated economy in the short-run, causing a heavy dependence on imports. The presently existing weak forward and backward linkages between sectors are cited among the problems existing in the Malaysian economy.

In addition, the planners' policy towards the industrial sector regarding the adoption of advanced technology resulted in production below its potential maximum in the short-run. This is because a number of structural "bottlenecks" developed, such as an insufficiently trained labour force and a lack of managerial and technical skills, as well as a heavily bureaucratic and hierarchical structure of organization.

This paper aims to assess the success or failure of Malaysian economic policy with input-output analysis. A static input-output model is used. Unfortunately, dynamic input-output models must be ignored, as the necessary capital matrix is not available for the Malaysian economy. The period of study is 1983 to 2000, during which time four input-output tables were established.

It would be expected that in resources-rich developing economy, such that of Malaysia, substantial structural change will take place over time. In particular, one might expect marked changes in the technologies employed, especially the nature of inter-industry trading. Also, change in the level and mix of final demand for produced goods would be expected to occur. One would anticipate that the role of state economic planning would be to facilitate and direct such developments.

Input-output analysis is well suited to the analysis of the nature of economic development through changing demand and changing technology. Thus this paper uses input-output methods to explore the success of economic planning in Malaysia. A variety of input-output techniques and concepts are employed. All lead towards the conclusion that economic integration has occurred in Malaysia during the period of study. Also, there is evidence of increasing efficiency in the Malaysian economy.

3. Theory and Literature Review:

There is wide range of possible measures of interrelatedness using input-output analysis. Most of these measures were proposed by authors in economics but there are some proposed by biologists, and have an ecological content (useful surveys of some of these measures are HAMILTON and JENSEN 1983, SZYRMER 1985, BASU and JOHNSON 1996, CAI and LEUNG 2004, and AMARAL et al 2007 and 2008). It used the measures proposed by economist for Malaysian economic analysis. These methods are listed with notation and range for these methods in Table 1.

Insert Table 1 Here

This paper shall concentrate on the Yan and Ames measure, as the most interesting interrelatedness method. However, it also relies on triangularisation method of ordering input-output tables.

3.1 Percentage Intermediate Transaction Method

One of the most obvious potential measures of interconnection is the percentage of the total production of industries in the economy which is used to satisfy needs for intermediate input. This measure was suggested by CHENERY and WATANABE (1958, p.492). For an input-output model this percentage can be mathematically expressed as:

$$I^{pit} = \frac{\underline{i}'\underline{Z}\underline{i}}{\underline{x}\underline{i}} * 100 \quad (1)$$

Here, $\underline{Z}$ is the transactions, or direct transactions matrix, $\underline{x}$ is the total output vector, and $\underline{i}$ is the unit (summation) vector. Those sales where the output of one sector satisfies the input demands of other sectors are the link which ties together the economy. Obviously, when a large fraction of input-output transactions are intermediate transactions, one can expect that the model under consideration is relatively well interconnected. The I^{pit} index, however, is insensitive to the diversity of these intermediate connections. For instance, one can imagine a model with only one huge transfer, while all other entries in the $\underline{Z}$ matrix are zero. According to this index, such a model can be well interconnected, but this result is hard to accept (SZYRMER, 1985; p.1594). The result for the Malaysian economy is shown in Table 3, row 1.

3.2 Average Output Multipliers Method

This is perhaps the most simple of the measures of interconnection. This measure was suggested by HAMILTON and JENSEN (1983; p.56) as a relatively good descriptor of interconnectedness. It is calculated as the arithmetical average of the sums of the columns of the Leontief inverse. The sector multipliers measure interconnectedness of each sector, whereas the average multiplier is an overall measure of interconnection of the economy. It can write this mathematically as:

$$I^{aom} = \frac{1}{n}\underline{i}'(\underline{I}-\underline{A})^{-1}\underline{i} \quad (2)$$

Here, n is the number of sectors in the input-output model. Notice that multipliers might be called technical measures of interconnectedness; they depend only on the direct or technical coefficients in the $\underline{A}$ matrix and are entirely independent of the actual sector importance, as measured by $\underline{x}$.

HAMILTON and JENSEN argue that greater interconnection means greater and more intensive impacts on particular sectors. By impacts, however, they presumably mean the effects of changes in final demands, which, by the nature of things, occur outside the system. Therefore, a greater output multiplier means stronger links between the external demand and the internal production, which is not automatically identical to intensive interconnections inside the model (SZYRMER, 1985; p. 1595). Thus the direct and indirect impact of a change in final demand for the output of industry j is the sum of the changed output levels in all n industries. Intuitively, the greater the interconnection, the greater and more widely spread will be the impacts on the various sectors.

An analogous measure of interrelatedness is proposed by BLIN and MURPHY (1974), namely, the average cell of the Leontief inverse, which is obviously identical to the average output multiplier divided by the number of sectors: I^{aom}/n. BLIN and MURPHY even claim the Leontief inverse expresses the total amount of input dependence of sector j on the output of sector i (BLIN and MURPHY, 1974; p. 438).

In contrast, percentage intermediate transactions might be called a specific measure, since it refers to a specific economy and depends on the relative importance of various industries, indicated by $\underline{x}$. The results of this measure for Malaysian economy input-output tables of 1983, 1987, 1991 and 2000, are given in Table 3, row 2.

3.3 Percentage Non-Zero Coefficients Method

This measure of interconnectedness was used by PEACOCK and DOSSER (1957; pp.21-24). It can be expressed mathematically as:

$$I^{pnc} = \frac{100 * \underline{i}'\underline{K}\underline{i}}{n^2} \quad (3)$$

Here, $\underline{K}$ is a matrix of the same dimension as the, $\underline{A}$, matrix and it can define this matrix by following:

$$K_{ij} = \begin{cases} 1, \text{if } a_{ij} \neq 0 \\ 0, \text{otherwise} \end{cases}$$

Since the multipliers, computed from the inverse matrix, seem intuitively to be related to economic interconnection, it seems reasonable to search for some summary statistic assessing the nature of the $\underline{A}$ matrix itself as a measure of interconnectedness. The intermediate coefficients are the links of interconnections, and more links suggest greater interconnection. Thus the percentage of the intermediate coefficients which are non-zero is one crude measure of interconnectedness (HAMILTON and JENSEN, 1983; p.57).

In the case of more highly interconnected models, the coefficients matrix, $\underline{A}$, is likely to have fewer zero entries. The result of this measure for interdependence of the Malaysian economy, for these input-output tables, is shown in Table 3, row 3.

The percentage non-zero coefficients is known in the ecological literature as direct connectivity, or conncetance, and is applied by many authors (GARDNER and ASHBY, 1970). It takes into account neither the specific position of the non-zero coefficients in the table, nor their magnitudes.

3.4 Coefficient Sum and Means Method

This measure calculates the mean intermediate coefficient total per sector, which shares most of the deficiencies of the percentage of non-zero coefficients. The measure uses not only the number of non-zero coefficients, but also the size of the coefficients in $\underline{A}$ as indicators of the degree of interconnection. It can be formulated mathematically as:

$$I^{mitps} = \frac{\underline{i'Ai}}{n} \quad (4)$$

Here, n is the number of intermediate sectors. This method was used by BURFORD and KATZ (1977; pp.21-38). They showed that the output multipliers were primarily determined by the column sums of the $\underline{A}$ matrix. JENSEN and WEST (1980) and HAMILTON (1979) also used the sum of the intermediate sector coefficients to compute a summary measure of model interconnectedness. Since the sum itself would be strongly related to the level of aggregation of the model, the sum was divided by the number of sectors to give mean intermediate coefficient total per sector. Notice that I^{mitps} is a technical measure of interconnection, being independent of $\underline{x}$. It deals only with direct relationship in an input-output model and ignores the specific positions of the input coefficients, but, unlike the index of the percentage of nonzero coefficients, it takes into account the magnitudes of the a_{ij} rather than just the number of non-zero coefficients. The results for this measure for the Malaysian economy are shown in Table 3, row 5.

3.5 Determinant Method

One of the more important mathematical characteristics of a matrix is its determinant. The determinant of the Leontief system $|\underline{I}-\underline{A}|$, was originally suggested as a measure of connectedness by WONG (1954; pp.283-341). Since, as is known from matrix algebra, the inverse of a matrix equals the adjoint divided by its determinant, one can expect that the smaller the denominator in this formula, the larger the elements of the inverse (HEAL, HUGHES and TARLING, 1974; p.87).

It might expect that smaller determinants would be associated with inverse matrices having larger elements, with larger multipliers, and with a greater degree of interconnectedness (HAMILTON and JENSEN, 1983; p.58). Since the determinant depends only on the direct coefficients, it is also a technical measure. However, the Leontief inverse per sector is not a perfect measure of interconnectedness. Moreover, the formula for $(\underline{I}-\underline{A})^{-1}$ should warn one of the fact that the elements of the Leontief inverse depend not only upon the value of the determinant, but also on the magnitudes of the respective adjoint matrix (SZYRMER, 1985; p.1596). Therefore, a low determinant does not automatically imply large entries in the Leontief inverse. The results for this measure for the Malaysian economy are shown in Table 3, row 6.

3.6 YAN and AMES Method

This method was initially suggested by YAN and AMES (1965; pp.299-310). The authors suggest the areas of potential application of their method may include inter-industrial diversity and specialization, technological change in the economy, and others (SZYRMER, 1985; p.1596).

3.6.1 YAN and AMES Matrix

For purposes of illustration of this method, consider an example as given by YAN (1969; pp.94-96). The author introduces a simple 4x4 technical coefficient matrix, $\underline{A}$, with three nonzero entries. To make this method simple to use, it will show the expansion series of the Leontief model for the matrix suggested by YAN and AMES. It shows the ordering of the sector that has connections with others in each round. It defines this matrix, $\underline{Y}$, with elements, y_{ij}. $\underline{Y}$ has the same number of rows and columns as $\underline{A}$. It is associated with each technical coefficient, $\underline{A}$, having non-negative elements. As the YAN and AMES method is an iterative method, the round of iteration is indicated by appropriate supscript, $\underline{A}^2$, $\underline{A}^3$, etc. Assume that each of these entries is 0.4:

First Iteration:

$$\underline{A} = \begin{bmatrix} 0 & 0.4 & 0 & 0 \\ 0 & 0 & 0.4 & 0 \\ 0 & 0 & 0 & 0.4 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad \underline{Y}_1 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad (5)$$

The next term, $\underline{A}^2$, shows the first-round indirect inputs required to produce the direct input $\underline{A}$. By performing the standard matrix multiplication, one can obtain the second-round matrix. This can be illustrated as follows:

Second Iteration:

$$\underline{A}^2 = \underline{A}*\underline{A} = \begin{bmatrix} 0 & 0 & 0.16 & 0 \\ 0 & 0 & 0 & 0.16 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad \underline{Y}_2 = \begin{bmatrix} 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 2 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{6}$$

The third term, $\underline{A}^3$, indicates the inputs required to produce the second-round indirect inputs, for:
Third Iteration:

$$\underline{A}^3 = \underline{A}*\underline{A}^2 = \begin{bmatrix} 0 & 0 & 0 & 0.064 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad \underline{Y}_3 = \begin{bmatrix} 0 & 0 & 0 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{7}$$

Fourth Iteration:

$$\underline{A}^4 = \underline{A}*\underline{A}^3 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad \underline{Y}_4 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{8}$$

This iteration has to be repeated until all higher-round matrices, are null. One can combine all the matrices, defined above as $\underline{Y}_1$, $\underline{Y}_2$, $\underline{Y}_3$, and $\underline{Y}_4$, in the following way:

$$Y_{ij}^{YA} = \min\{Y_{1ij}, Y_{2ij}, ..., Y_{kij}\} \tag{9}$$

For $Y_{kij} \neq 0$, for all K_{ij}, i.e., $\underline{Y}$ contains the smallest non-zero elements in the Y_k matrices. The result for the order matrix of the example above is as follows:

$$\underline{Y}^{YA} = \begin{bmatrix} 0 & 1 & 2 & 3 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{10}$$

Following the notation of YAN and AMES, we substitute ∞ for zero elements in this matrix. Then the matrix appears as follows:

$$\underline{Y}^{YA} = \begin{bmatrix} \infty & 1 & 2 & 3 \\ \infty & \infty & 1 & 2 \\ \infty & \infty & \infty & 1 \\ \infty & \infty & \infty & \infty \end{bmatrix} \tag{11}$$

YAN and AMES have suggested a general form of this matrix, $\underline{Y}^{YA}$. They set $y_{ij} = k_{ij}$ instead of the numbers in the form (11), as follows:

$$\underline{Y}^{YA} = \begin{bmatrix} \infty & k_1 & k_2 & k_3 \\ \infty & \infty & k_1 & k_2 \\ \infty & \infty & \infty & k_1 \\ \infty & \infty & \infty & \infty \end{bmatrix} \tag{12}$$

Where, $1/\infty = 0$ and k = 1, 2, …, n. Then, the order matrix, $\underline{Y}^{YA}$, attributed to the $\underline{A}$ matrix appears as shown above. Each entry, Y_{ij}^{YA}, in the order matrix, $\underline{Y}^{YA}$, represents the smallest order of relatedness between i and j. That is, it is equal to the number of input-output rounds which are needed for the first i-j connection to occur. Obviously, there are precisely three connections for first order, two of second, and one of the third, which are appropriately recorded by the order matrix, $\underline{Y}^{YA}$.

3.6.2 YAN and AMES Interrelatedness Function

$\underline{Y}^{YA}$ can be used to define an interrelatedness function. This measure considers only the existence of input-output relations between industries and disregards the magnitude of transactions; it indicates the relatedness (both direct and indirect) of industries. This measure is a technical measure also, since it does not rely on $\underline{x}$.

Next, we define an interrelatedness function. This function, in its most aggregate version, is expressed by a single number, the interrelatedness index, I^{YA}. Then, the interrelatedness function can be computed mathematically from Y^{YA}, for each row, as,

$$I_i^{YA} = \frac{1}{n}\sum_{j=1}^{n}\frac{1}{y_{ij}} \tag{13}$$

This expresses the sensitivity of a given sector to changes in the other sectors. Alternatively, it can calculate,

$$I_j^{YA} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_{ij}} \tag{14}$$

This expresses the sensitivity of all other sectors to impacts on a given sector. The overall measure of interconnection of the economy is computed as the average of the reciprocals of entries of the $\underline{Y}^{YA}$ matrix:

$$I^{YA} = \frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{1}{y_{ij}} \tag{15}$$

In particular, if i=j=1, then $I^{Ya} = \frac{1}{y_{ij}}$. In the example show above, I^{YA} = 0.27. The results for the Malaysian economy are shown in Table 3, row 7.

It will be noted that the YAN and AMES interrelatedness function is the reciprocal of the harmonic mean of the elements of the appropriate sub-matrix of $\underline{Y}$ (YAN and AMES, 1965; p.300). The value of I^{YA} is thus uniquely defined for any sub-matrix of $\underline{Y}$, and hence for any matrix $\underline{A}$ with non-negative elements. Observe that $0 \leq I^{YA} \leq 1$; I^{YA} =1 if the corresponding elements of $\underline{A}$ are strictly positive, and I^{YA} =0 if all the corresponding elements of $\underline{Y}$ are infinite. The matrix $\underline{Y}$ and the function I^{YA} depend not only on the number, but also the location of the non-zero elements of $\underline{A}$. This is the main reason, as it mentioned earlier in this paper; the interrelatedness function relies on the triangularisation technique.

One further observation about the interrelatedness function is needed. If ($n_1, n_2, \ldots, n_n$) denote the number of elements of a sub-matrix of the order matrix whose values are equal to (1, 2, …, n), then the interrelatedness function may be rewritten:

$$I^{YA} = \frac{1}{n^2}\sum_{k=1}^{\infty}\frac{n_k}{k} \tag{16}$$

In particular, we may isolate the first term in this series, so that:

$$I^{YA} = \frac{n_1}{n^2} + \sum_{k\neq 1}^{n}\frac{n_k}{k\,n^2} \tag{17}$$

The first right-hand term measures the proportion of elements of the order sub-matrix which are equal to 1; that is, the proportion of the elements of the sub-matrix of $\underline{A}$ which are non-zero. This term will be referred to as the index of diversification, and the second term will be referred to as the index of indirect relatedness (YAN and AMES, 1965; p.300). The concept of diversification has economic content if the sub-matrix in question is (1xn) or (nx1) or (nxn). In the fist case, the term n_1/n represents the proportion of industries to which a given industry sells; in the second case, it represents the proportion of industries from which a given industry buys, in the third case, n_1/n^2 represents the proportion of the mathematically possible kinds of direct relations which are actually realised.

The index of diversification for the Malaysian economy has been calculated and is shown in Table 5. The interpretation will be discussed later in this paper (see Section 4).

Diversification is taken to be opposite of specialization, in which an industry has few customers, or suppliers, and an economy is characterised mainly by indirect relations.

4. Interpretation of Empirical Results:

The aim of this section is to apply the methods and techniques as described in the previous section. The four input-output tables for the Malaysian economy are identified in Table 2 with some important characteristics of the input-output tables.

These characteristic refer to:

The order of the respective matrices in terms of sectors (row 1) and intermediate cells (row 2).

The total value of the transactions recorded in the intermediate quadrant (row 4).

Also, Table 2 shows some measures of the degree of interconnectedness, or the strength of intersectoral linkages, in each matrix. These measures include:

The percentage of cells initially with a value of zero (row 3).

The total of all coefficients in the intermediate quadrant (row 5).

The mean coefficient total per sector of the intermediate quadrant (row 6).

The last of these, effectively measured as the sum of the a_{ij} of the intermediate quadrant divided by the number of sectors, was accepted as an interim measure of interconnectedness in the national economy. It will be noticed that this measure of interconnectedness has some positive correlation with the total of the intermediate coefficients (row 5), and the total of the intermediate transactions (row 4). Also, this measure has an inverse correlation with the percentage of zero cells in the initial table (row 3).

These six measures of economic interconnectedness were applied to the four input-output tables of the Malaysian economy. The results are shown in Table 3.

Table 3 reveals the following:

According to the percentage intermediate transaction measure, and coefficient sum and means index, it seems that the Malaysian economy was rapidly changing in the period 1980-2000. This follows from the interconnections in the Malaysian economy increasing over time during that period.

As it see from the results measured by average output multipliers, the interrelatedness of the Malaysian economy in 1983 was similar to that for 1987 and 1991.

The interrelatedness is similar for the tables for 1983 and 1987, and for 1991 and 2000 as measured by percentage non-zero coefficients.

If it considers the interrelatedness as measured by I^{YA}, there is some increase for Malaysia Economy for the period 1980-2000.

The determinants method suggests that the change in the Malaysian economy is high for the period under study. It could be interpreted that developments in the Malaysian economy was very high over the period 1980-2000. However, this measure has positive correlation with average output multipliers.

It has examined the sequence $a_{ij}, a_{ij}^2, a_{ij}^3, \ldots, a_{ij}^n$ for the Malaysian economy by the same procedure as in the example, in the previous section (3.6.1). Equation (17) has been applied to the tables as mentioned above. The results are shown in Table 3, row 8.

It can be seen at a glance from $\underline{K}$ matrices as it identified in section 3.3, which industries are connected with all sectors and which industries have few interrelations, such as these sectors are shown in the table (4).

From Table 3 it is rather difficult to get much feel for the effectiveness of the various measures. Most of them behave quite systematically, the most obvious exceptions being the erratic performance of several measures when applied to the national table for 2000.

It may now consider the empirical connections between diversification and interrelatedness. This connection may be viewed either in term of the economy as a whole, or of particular industries. Here the researcher considers the whole economy rather than individual sectors. Table 5 gives a frequency distribution of the element of the 1983, 1987, 1991 and 2000 technological order matrices, and the values of the interrelatedness function and diversification Index for these matrices.

Table 5 shows that the increase in interrelatedness was by (0.007) in the period of study. Nevertheless the diversification was decreased by (-0.02). That is, it is not exceeded the increase in interrelatedness, because there was a small decrease in indirect relatedness in the economy.

5. Performance of the Interconnectedness Measures:

When judging the performance of these six measures of interconnectedness, it is important to realize that there is no objective standard against which to compare their effectiveness. There is no recognised perfect measure in the input-output literature. Hence, any judgment must be based on the underlying logic of the measure itself, and on any inconsistencies or ambiguities that result when the measures are used.

Of the six interconnectedness measures evaluated in this paper, five were technical measures based only on the coefficients in the matrix $\underline{A}$. The only specific measure incorporating information on sectoral output level, $\underline{x}$, is the percentage intermediate transaction. It is hardly surprising to find that such a measure behaves erratically when compared with any of the five technical interconnectedness measures. Percentage intermediate transactions in such a situation can show a high degree of interconnection, even though most of the sectors in the economy are in fact only slightly interconnected, as is clearly the case in the Malaysian economy in 2000; while the degree of interconnectedness is 30.3, the percentage of cells initially zero is 6.68%.

In contrast, if a national economy has a large enclave industry, which exports most of its output, and relies mostly on imported inputs, then percentage intermediate transactions will detect this condition better than the technical measures, because it is the only measure which incorporates information about sector size. The only measure insensitive to aggregation is percentage intermediate transactions, which is probably best relegated to instances of extreme sector size imbalance (HAMILTON and JENSEN, 1983; p.65).

The implication, of course, is that when comparing the interconnectedness of economies by means of one of these five measures, the measures should be based on table with a common level of aggregation. In the ideal situation, where accounting system and model size are both constant, and where the sector sizes are not extremely imbalanced, the choice of an ideal measure is clear. Average output multipliers have the virtue of a strong underlying theoretical logic. Yet in such circumstances there is an almost one-to-one corresponding between mean intermediate coefficient total, average output multiplier, and determinant, suggesting that these measures are all equally good. If that is true, then the choice for an operational measure of interconnectedness goes to the measure that is easiest to compute, which is mean intermediate coefficient total per sector.

6. Policy Implications:

Malaysia has long involved in the economy spheres with evolution in its economics transitions from agricultural-based, production-based, services-based, and now the most talk about knowledge-based economy. With Malaysia nearly reaching to its half-century life span at 47 year-old, nevertheless the country's economic performance thus far have seen broad-based growth even with some hitches in the economic arena regardless of global or local platforms. In spite of the continuing uncertainties and underlying structural weaknesses, Malaysia has overhauled and further enhanced the resilience of the Malaysian economy with greater balance between domestic and external sources of growth, between the role of the private and public sectors, among the performance of various sectors in the economy (CHING, 2006).

Over the years, Malaysia economy has seen tremendous transformation across all segments of the economy. While the Malaysian economy was affected by the unavoidable external developments in the global phenomena, it has to a certain extent successfully focus its policies and economic development activities in directing the nation towards sustaining domestic demand and promoting domestic sources of growth. With that in mind, it has effectively contributed towards the well-balanced growth for Malaysia to surf on the evolving wave in realizing the Vision 2020 as the national long-term goal.

The aims and the theoretical basis of Malaysian economy planning were discussed early in this paper, especially since 1970. To briefly summarise, interrelatedness is a concept in economic development models which has emerged to investigate the relationship between sectors. Now Malaysian development planning policies have tried to place the emphasis on electronic industry, in which Malaysia has a comparative and absolute advantage, as a base for future industrialization. This type of industry, however, depends almost entirely on industry product as its raw material. This therefore implies the need for a long-term conservation objective, while at the same time strengthening the linkages between this sector and the rest of the economy.

The development planning in Malaysia was aimed at creating an interrelationship between the sectors, bringing the benefits; it was hoped, of indirect gains of external economies and the transfer of technology and know-how. These processes are thought to have been the utmost importance for the development process, promoting backward and forward linkages throughout the domestic economy.

The planners have allocated the large investment made in the Malaysian economy since 1970, and these have increased in size over time (CHING, 2006). In view of this high level of investment, the degree of interconnectedness in the Malaysian economy would be expected to produce a high interrelatedness function.

The results shown in Table 2, 3, 4, and 5, and discussed in the previous sections, show how far this policy has been successful. The tables show that some progress has been made, but it falls far short of what the planners aimed to achieve. As it has seen in Table 4, the crude oil sector still has negligible interrelations with economy. So, we can conclude that the intersectoral between sectors, as it can be seen in the Tables (2,3, and 5), still remains weak.

However, the planning policy for the future development of the Malaysian economy was purposely designed around a clear picture of the integration process among the various economic sectors. It aimed at channeling the output of the Agriculture sector away from exports and into the domestic manufacturing sectors, especially, rubber and Palm oil. The policy also put more emphasis on the manufacturing industries which depended on domestic raw materials (CHING, 2006).

This policy of integration has also focused on the agricultural sector, because agriculture is still the backbone of development in every LDC, particularly Malaysia which is rich in agricultural resources (ISMAIL, 2006).

7. Conclusions and Further Studies:

According to the results shown previously, it can be said that there has been little increase in the interrelatedness among the sectors in the Malaysian economy. In this paper we have explored some of the input-output techniques to measure the success of connectedness in the Malaysian economy.

The interrelatedness between sectors, as measured by connectedness methods, was still very weak; because the commodities sectors have failed to play a leading role in accelerating economic development. They did not become a growth pole for the diffusion of technical progress.

However, this sort of analysis needs to consider a more fundamental set of objectives than interrelatedness of input-output relationships. Investment is not usually considered as an objective, but as proxy for an increasing efficiency of the economy. However, if we consider increasing efficiency over time as our objective, then each investment needs to be evaluated in terms of its direct and indirect effect. This can be done by reference to the Linkages and Multipliers techniques using input-output methods which could be discussed for further papers. Also, the results of this empirical research need to be carefully examined and we plan to do in the immediate future.

References

AMARAL, J.F.; DIAS. J., and LOPES, J. (2007). Complexity as Interdependence: A new Measure of Connectedness of Input-output Systems, *Environment and Planning A,* Vol.39, pp.1170-1182.

AMARAL, J.F.; DIAS. J., and LOPES, J. (2007). Economic Complexity as Input-Output Interdependence: A Comparison of Different Measurement methods, *Proceedings of the 16th international Input-output Conference*, Istanbul, Turkey, 2-6 July.

AMARAL, J.F.; DIAS. J., and LOPES, J. (2008). Assessing Economic Complexity in some OECD countries with Input-output Based Measures, *International Conference on Policy Modeling*, Berlin, Germany, July 2-4.

BASU, R. and JOHNSON, T.G. (1996). The development of a measure of intersectoral connectedness by using structural path analysis, *Environment and Planning A*, Vol.28, pp. 709-730.

BEKHET, H.A. (1997). Toward restructuring the economy as a base for development planning, *Journal of Economic and Administration Science*, Vol.4, No.12, Baghdad University.
BEKHET, H.A. (1998). Analyzing input-output to measure the two gaps of production and employment for Iraqi Economy, 1976-1990, *Journal of Economic and Administration Science*, Vol.5, No.13, Baghdad University.
BEKHET, H.A. (1999). Structural change analysis of the Iraqi economy for the period 1978-1988 with an input-output approach, *Dirasat Journal, Administrative Science Division*, Jordanian University, Vol.26, N0.2.
BLIN, J.M. and MURPHY, F.H. (1974). On measuring economic interrelatedness, *Review of Economics and Statistics*, Vol. 41, 437-440.
BURFORD, R.L., and KATZ, J.L. (1977). Regional input-output multipliers without a full input-output table, *Annals of Regional Science*, Vol.11, pp.21-38.
CAI, J., and LEUNG, P. (2004). Linkage measures: A revisit and a suggested alternative, *Economic Systems research*, Vol.16, pp.65-85.
CHENERY, H.B., and WATANABE, T. (1958). "International comparisons of the structure of production, *Econometric a*, Vol.26, pp.487-521.
CHING, P.W. (2006), *The Development of Malaysian Economy* (6th ed), PEARSON-Prentice Hall, Malaysia, KL.
Department of Statistics, Malaysia (DOSM) (2005b). *Input-Output Tables*, Malaysia, Putrajaya.
DIETZENBACHER, E., and LOS, B. (2002), Externalities of R&D Expenditures, *Economic Systems Research*, Vol.14, pp.407-425
DRIDI, C., and HEWINGS, G. (2002), Industry associations, Association Loops and Economic Complexity: Application to Canada and the United State, *Economic Systems research*, Vol.14, pp.275-296.
Gardner, M.R. and Ashby, W.R. (1970). Connectance of large dynamic (Cybernetic) systems: *Critical values for stability*. Nature 228:784.
GHOSH, A. (1985), A characterization of the 'heuristic solution' of the optimal ordering problem of an input-output matrix as a Nash point with some further observations on the ordering problem as a game", *Economics of Planning*, Vol.19, pp. 118-125.
GHOSH, A., and BUGUMBE, K. (1981). "Computation of an optimal ordering for an input-output matrix by an application of dynamic programming, *Economics of Planning*, Vol.17, pp. 20-22.
GHOSH, A., and SARKAR, H. (1970). An input-output matrix as a spatial configuration", *Economics of Planning*, Vol.10, pp. 133-142.
GIM. H.U., and KIM, K. (2008). A study on the building of a new "output-output model" and its usefulness: based on a comparative analysis of the input-output model, *Annual Regional Science*, Vol.22 (Online).
HAMILTON, J.R. and JENSEN, R.C. (1983). "Summary measures of interconnectedness for input-output models", *Environment and Planning A*, Vol.15, pp.55-65.
HEAL, G.; HUGHES, G., and TARLING, R. (1974), *Linear Algebra and Linear Economics*, Macmillan, London, p.87.
ISMAIL, F. HJ. (2006). "Structural Change of the Agricultural Sector: Analysis Based on Input-Output Tables", *International Workshop on Agriculture Economic Analysis in Bangkok*, Thailand on 13-15, March, 2006.
JENSEN, R.C. and HEWINGS, G.J.D. (1985). Shortcut Input-Output Multipliers: a Requiem, Environment *and Planning A*, Vol.17, pp.747-759.
JENSEN, R.C. and WEST, G.R. (1980). "The effect of relative coefficient size on input-output multipliers", *Environment and Planning A*, Vol.12, pp.659-670.
LOPES, J.C; AMARAL, J.F., and DIAS, J. (2005). A new Interrelatedness indicator to measure Economic Complexity, with an application to the Portuguese case, *Fifteenth International Input-Output Conference*, Renmin University of China, Beijing, China, 27 June-1 July.
Malaysia, Department of Statistics (2002). *Malaysian Input-Output Table for 1991*, Malaysia.
Malaysia, Department of Statistics (2005), *Malaysian Input-Output Table for 2000*, Malaysia.
OKUYAMA, Y. (2007). Economic Modeling for Disaster impact analysis, *Economic systems Research*, Vol.19, pp.115-124.
PEACOCK, A. and DOSSER, D.G.M. (1957). "Input-output analysis in an underdeveloped country: a case study", *Review of Economic Studies*, Vol.25, pp.21-24)
ROBINSON, S., and MARKANDYA, A. (1973). Complexity and adjustment in input-output systems, *Oxford Bulletin Economics and Statistics*, Vol.35, pp.119-134.
SONIS, M., and HEWINGS, G.J.D. (1998). Economic complexity as network complication: Multiregional input-output structural path analysis, *Annals of Regional Science*, Vol.32, pp.407-436.
SONIS, M.; GUILHOTO, j.; HEWINGS, G.J.D., and MARTINS, E. (1995). Linkages, key sectors and structural change: some new perspectives, *Developing Economies*, Vol.33, pp.233-270.
STEINBACK, S.R. (2004). using ready-made regional input-output models to estimate backward-linkage effects of exogenous output shocks, *Review of Regional Studies*, Vol.34, pp.57-71.
STOVER, M.E. (1994). A comparison of annual and benchmark input-output tables in regional economic modeling, *The Annals of Regional Science*, Vol. 28, pp.223-228.
SZYRMER, J.M. (1985), "Measuring connectedness of input-output models: 1. survey of the measures", *Environment*

and Planning A, Vol.17, pp.1591-1612.
SZYRMER, J.M. (1986), “Measuring connectedness of input-output models: 2. Total flow concept”, *Environment and Planning A*, Vol.18, pp.107-121.
WONG, Y.K. (ed.) (1954). *Some Mathematical Concepts for Linear Economic Models*, McGraw-Hill, New York, PP.283-341.
YAN, C. (1969), *Introduction to Input-output Economics*, Holt, Rinehart and Winston, New York.
YAN, C., and AMES, E. (1965). “Economic interrelatedness”, *Review of Economic Studies*, Vol.32, pp.299-310.

Table 1. List of Measures

Measure	Notation	Range
Percentage of Intermediate Transaction.	I^{pit}	(0, 100)
Average Output Multipliers.	I^{aom}	(1, ∞)
Percentage of nonzero Coefficients.	I^{pnc}	(0, 100)
Coefficient Sum and Means Method.	I^{mitps}	(0, 1)
Determinant of (I-A).	I^{det}	(0, ∞)
YAN and AMES Index.	I^{YA}	(0, 1)
Diversification Index.	I^{der}	(0, 1)

Table 2. Identification and Characteristics of input-output Tables for Malaysian Economy.

Measure	Input-Output Tables			
	1983	1987	1991	2000
Intermediate sectors	60	60	92	92
Intermediate cells	3600	3600	8464	8464
Cells initially zero	171	155	515	565
Total intermediate transaction	45,264,180	50,565,283	102,330,738	271,699,945
5. Total intermediate coefficients	21.11	21.00	32.693	34.305
6. Mean coefficient total per sector	0.352	0.354	0.355	0.373

Source: Malaysian Input-Output Tables for 1983, 1987, 1991 and 2000.

Table 3. Measures of Interconnectedness for Input-Output Tables or Malaysian Economy

Measure	Input-Output Tables			
	1983	1987	1991	2000
1. % intermediate transaction	18.8	17.7	19.3	30.30
2. Average output multipliers	1.53	1.53	1.54	1.58
3. % nonzero coefficients	95.3	95.6	93.9	93.37
4. % of cells initially zero	4.75	4.33	6.08	6.68
5. Mean Intermediate Coefficient sum	0.352	0.354	0.355	0.373
6. Determinant of (I-A)	0.064	0.071	0.012	0.003
7. Yan and Ames	0.956	0.973	0.964	0.963

Source: Malaysian Input-Output Tables for 1983, 1987, 1991 and 2000.

Table 4. Sectors have few interrelations

	Input-Output Table			
	1983	1987	1991	2000
1	Livestock	Livestock	Livestock	Coconut
2	Foresting	Foresting	Fishing	Tea Estate
3	Fishing	Fishing	Crude oil	Fishing
4	Private non-profit services	Private non-profit services	Ownership dwelling	Ownership dwelling

Source: Malaysian Input-Output Tables, 1983, 1987, 1991 and 2000, Department of Statistics, Malaysia.

Table 5. Technological Interrelatedness in the Malaysian Economy

Order of Interrelatedness	Number of Elements of Technological Order Matrix			
	1983	1987	1991	2000
1	3429	3445	7949	7899
2	111	95	239	382
3	60	60	276	183
∞	0	0	0	0
Total	3600	3600	8464	8464
I^{YA}	0.956	0.973	0.964	0.963
I^{der}	0.953	0.957	0.939	0.933

Source: Malaysian Input-Output Tables, 1983, 1987, 1991 and 2000, Department of Statistics, Malaysia.