An Efficient Method for Constructing Regional Input-Output Table: A Horizontal Approach in Indonesia

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ABSTRACT

There seems to be general agreement in input-output analysis that hybrid method is the most feasible method for constructing regional input-output tables (Lahr 1993; Van der Westhuizen 1992; West 1990). The hybrid method appears to be the most cost-effective with acceptable accuracy. The method takes the advantages both survey and non-survey methods for constructing regional input-output tables and avoid the disadvantages. The accuracy is considered as the advantage of survey method, while the speed and low cost are well-known characteristics of non-survey method.

The horizontal method takes the advantage of the availability of a set regional tables in Indonesia. In addition, the identification of the fundamental economic structure (FES) with its properties is the main focus. This current research is the development of horizontal approach to construct regional input-output tables based on the FES in Indonesia. The previous FES approach developed by Van der Westhuizen (1992;1997) and Imansyah (1997) have some weaknesses and a revised FES approach was suggested.

The criteria and procedures of horizontal approach have been established. The sequence of procedures is outlined. An initial requirement of the FES approach is the availability of several regional input-output tables. These tables are used as reference tables. Based on these reference tables, regression analysis is used to identify the FES. The results of regression analysis indicate the existence of the FES and the strength of a relationship between transaction flows and aggregate economic indicators.

The adjusted R^2 of the regression analysis is used to measure the predictability property of the FES. Stability property is measured by the coefficients of variation in the input-output coefficients across the reference tables, while a sensitivity analysis identifies the important cells.

Identification of the FES properties establishes the first approximation of the initial intermediate transaction cells. The estimation of the first approximation of transaction cells is based on the regression analysis results. If the cells do not meet this criterion, the stability of the cells must be checked. The stable cells can use the coefficients of the average regional tables. The unstable cells are checked using sensitivity analysis to determine whether these cells are important. If these cells are important, superior data is used for these cells. However, if these cells are unimportant, the coefficients of the average regional tables can be used.

Using the above estimation/mechanical procedure, analyst can construct the first approximation of regional input-output tables. This procedure can estimate approximately 85-90 per cent of non zero cells at 21 sectors aggregation in Indonesia. Only 10-15 per cent of non-zero cells need be estimated by superior data. This means that the procedure is relatively efficient. The performance of the suggested procedure is satisfactory with respect to holistic accuracy. The results of this procedure are satisfactory. Most of the errors are less than 10 per cent.

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1. Introduction

There seems to be general agreement in input-output analysis that the hybrid method is the most feasible method for constructing regional input-output tables (Lahr 1993; Van der Westhuizen 1992; West 1990). The hybrid method appears to be the most cost-effective and well within the range of acceptable accuracy. This method mixes the advantages of the survey and the non-survey methods for constructing regional input-output tables and avoids the disadvantages. Accuracy is considered the main advantage of survey method, while the speed and low cost are well-known characteristic of non-survey method for constructing regional input-output tables. High cost and time requirement are the main disadvantages of survey method. In contrast, less accuracy is the main disadvantage of non-survey method.

Hybrid methods cover three approaches: top down, bottom up and horizontal. The top down approach is the most recognised and widely used due to the availability of national input-output tables. This approach takes advantage of the availability of national input-output tables as reference tables. On the other hand, the bottom up approach appears to be appropriate for small regions only because resources are based on regional data. Therefore, the larger the region, the more data is required. The horizontal approach is usually assumed for updating regional tables. The horizontal approach uses other regional input-output table as the basis for the first approximation. However, in the hybrid method context, some issues emerge. For example, how to choose reference tables and how to insert superior data. There are two important issues for the development of the horizontal approach. The study of economic structure is one effort to help analysts to determine the choice of reference tables. Another major issue is the insertion of superior data.

Jensen West, and Hewing (1988) provided a useful insight into the similarities of regional economies. The information contained in the fundamental economic structure (FES) can be used to construct another regional input-output table. However, this potential technique has not been explored fully.

This paper outlines a hybrid procedure using the FES approach for constructing regional input-output tables. Section 2 provides a short review of three approaches for constructing hybrid regional input-output tables. Section 3 critically reviews previous implementation of the FES for the construction of regional input-output tables. Section 4 suggests a revised FES approach. This section describes properties of the FES approach, such as predictability, stability and importance. The discussion of the properties includes the definition, the objective of the identification, the implication, and the measurements. Section 5 describes the sequence of the FES procedures. The performance of the FES approach is discussed in section 6. The last section provides a summary and conclusions.

2. Hybrid Approaches Revisited

2.1. Top Down Approach

This approach uses national input-output tables to produce regional input-output tables by using mechanical regionalisation techniques such as LQ, RPC and others. This mechanical table derived is the first approximation for producing regional input-output tables. The most common top-down procedure used in Australia is the hybrid GRIT (Generation of Regional Input-Output Table) method developed by Jensen and his colleagues (Jensen, Mandeville and Karunaratne 1979). The GRIT procedure involves the application of location quotients to derive regional input-output coefficients from the national table as the first approximation (West, 1981b). Superior data are then inserted into the table to improve the initial estimation. This is a critical step. The insertion of superior data based on *a priori* information or local knowledge of the economy under study makes the table holistically accurate (Jensen 1977).

However, *a priori* information and local knowledge of the economy are relatively subjective and it is difficult to determine how much superior data should be used and what parts of the table must be reestimated. In addition, a conflict between local expert opinion and other secondary data is a problem when constructing input-output tables (Jackson, Israilevich & Comerr 1992). Jackson, Israilevich and Comer suggested that all published data should define the process of data collection clearly so that other researchers can evaluate the results.

2.2. Bottom Up Approach

The bottom up approach uses local data for estimating regional input-output tables. One such bottom up approach, called ASSET (A System for Small Economy Table), was used to produce regional input-output tables for the town of Cooroy, Queensland (Smith 1983, Smith & Jensen (without year)). The data needed to construct a table is based on the cost structure of representative firms and other secondary data. While other hybrid methods rely on the national table as the first approximation, the ASSET procedure uses region specific data. The initial procedure is to collect a pool of "representative firm" data containing cost structures which can be used to construct an initial coefficients table. The second phase is to convert the technical coefficients to trade coefficients by estimating the leakages due to imports. The third phase is to insert superior data and perform a sensitivity analysis to derive the final table. This phase is very important in order to ensure that coefficients are free from significant error. The drawback of the bottom up approach is in the estimation of regional imports because a small region does not usually record export and import (transaction) flows. Harmston and Lund (1967) suggested that small economic communities use purchasing data to estimate the initial coefficient matrix.

2.3. Horizontal Approach

Updating the same regional table is also included in this category. The RAS method is often used for updating a regional table. However, in the hybrid philosophy, the “modified RAS” is preferred, which “locks in” any superior data that have been inserted, hence only ‘insignificant’ cells are allowed to change.

Hewings (1977) evaluated the possibility of borrowing regional input-output coefficients to develop another regional input-output table. He applied simulation methods using the Washington 1963 and Kansas 1965 survey-based tables. The result was satisfactory when the RAS method was used. Similarly, Antille (1990) tried to construct an input-output table for Switzerland by borrowing Germany’s input-output table. However, it is very difficult to borrow other survey-based regional tables as comparable survey-based tables are not always available for this purpose.

Van der Westhuizen (1992) tried to implement the concept of the FES in the construction of regional tables. This approach can be considered as a horizontal approach because several regional input-output tables of similar regions are used as reference bases.

3. Initial Implementation of FES Approach

The term, fundamental economic structure (FES), was initially introduced by Jensen, West and Hewings (1988). They developed in attempting to identify similarities rather than differences in region’s economic structure. They identified the existence of the FES in Australian regional economies. However, they did not proceed to implement this concept into the construction of regional input-output tables. Later, Van der Westhuizen (1992) explored the use of the concept of FES to construct hybrid tables. He used nine tables of South African regions to establish the existence of the FES and used this as the basis for his analysis. Using this approach, Van der Westhuizen developed a model for constructing regional tables. The results showed that the new method was satisfactorily accurate with three different levels of aggregation (9-, 19-, and 32-sectors). The summary of this method of constructing other regional tables is shown in Table 1.

Van der Westhuizen (1992) defined three properties to categorise input-output cells: importance, stability and predictability. He defined importance as the reflection of the relationship between economic interaction (input coefficient) and the rest of the economic system. If the potential impact of the change in coefficients is significant on the rest of the economic system, the coefficients are important. To identify the important cells, Van der Westhuizen used several approaches, such as the average size of input coefficients, the average level of connectivity (Bosserman index), and the inverse important parameter. The calculation is based on the average of the regional tables.

Stability deals with variations in the input coefficients in different regions. Several methods are used to measure stability, such as the Boolean matrix and percentage relative dispersion.

Predictability refers to the economic relationship that can be predicted using some aggregate indicator, such as gross regional product or sectoral employment to measure economic activity.

Unfortunately, Van der Westhuizen (1992) did not explain how to classify each cell within each group of the criteria in Table 1, for example he did not explain how to differentiate between important and mildly important. In addition, Van der Westhuizen did not mention how to classify the cells according to the properties defined previously. The available and identified methods of measurement provide no clarification. Thus, a comparison and evaluation of this analysis with others are difficult. Further, a repeating or applying of this method to other data is not feasible as the exact parameters used in the initial study are unknown.

Table 1.

Criteria for Developing a Projection Matrix Using the Properties Of Importance, Stability and Predictability

Properties			Projection Matrix
Importance	**Stability**	**Predictability**	**Data**
Important	Stable	Predictable	Base
		Mildly predictable	Base
		Unpredictable	Base
	Mildly Stable	Predictable	Predict
		Mildly predictable	Survey
		Unpredictable	Survey
	Unstable	Predictable	Predict
		Mildly predictable	Survey
		Unpredictable	Survey
Mildly Important	Stable	Predictable	Base
		Mildly predictable	Base
		Unpredictable	Base
	Mildly Stable	Predictable	Predict
		Mildly predictable	Predict
		Unpredictable	Survey
	Unstable	Predictable	Predict
		Mildly predictable	Predict
		Unpredictable	Survey
Unimportant	All	All	Base

Source: Van der Westhuizen (1992) Table 2.11

The data used for the first approximation in Van der Westhuizen's work still relies heavily on national data for important (including mildly important), stable and predictable (or even unpredictable cells) (see Table 1). The national data is used as the base data for the estimation. Therefore, this FES approach cannot be considered as a pure horizontal approach. Van der Westhuizen used three groups of data sources for constructing his transaction matrix. The first group was the base data. This base data was based on national input-output data. The second group was the prediction data (regional data). This data was based on the use of regression estimation. The third group was the survey data (superior data).

Every criterion of the FES approach determines the source of data to be used. For example, if a cell is identified as important, stable, and predictable, then the estimation uses base data (national data). However, if a cell is identified as important, mildly stable and predictable, then the estimation uses the prediction from the regression results.

However, the criteria developed by Van der Westhuizen (1992) in Table 1 are complicated and consist of subjectively vague terms such as mildly stable or mildly predictable. The threshold of the criteria for classifying each cell is not defined clearly, and in a practical sense, these criteria are also difficult to apply.

4. A Revised FES Approach

To avoid some weaknesses of the Van der Westhuizen (1992) study, the present study used a revised FES approach to establish the criteria for constructing regional input-output tables. A modification of the criteria is suggested which are easier and simpler to apply. The straightforward revised criteria are shown in Table 2.

In addition, the approaches to meet the criteria are also clearly defined for this study. Many approaches are used to examine the pattern of the properties. As in Van der Westhuizen's methodology, input-output cells are used as the basis for the criteria. The properties and measurements are discussed in the next section.

4.1. Predictability

The FES concept defined predictability as *the degree to which some elements are present in varying amounts, the size of which may be predictable using some aggregate measures of an economy (e.g. gross regional product or national product, the degree of industrial concentration* *ratio by sector)* (Hewings, Sonis & Jensen 1988b, p. 164). This term implies that some elements of an economic structure can be predicted using aggregate economic indicators. It also implies that elements in some regions share similarities with elements in other regions that have the same aggregate economic indicators. In other words, the predictability of an economic structure might be related to the regularities of structural change. For example, the economic structure of two regions can be expected to be similar if their economic size or their level of development is similar.

Table 2.

Criteria for Developing Hybrid Table using Revised FES Approach

Characteristics			**Initial Table**
Importance	**Stability**	**Predictability**	**Data sources**
Important	Stable	Predictable	Regression estimation
	Unstable	Unpredictable	Superior data
	Stable	Unpredictable	Estimate by other means (Av. Coeff.)
	Unstable	Predictable	Regression estimation
Unimportant	Stable	Predictable	Regression estimation
	Unstable	Unpredictable	Estimate by other means (Av. Coeff.)
	Stable	Unpredictable	Estimate by other means (Av. Coeff.)
	Unstable	Predictable	Regression estimation

Borrowing a term from economic development theory, predictability can be regarded as a parallel with the term "stylish facts" or uniform features of development (see, for example, Chenery & Watanabe 1958; Chenery & Taylor 1968; Kuznet 1957; Syrquin 1988). Some analysts argue that most countries follow a regular pattern of development. Therefore, a structural economic transformation based on this common pattern can be expected. For example, Clark (1940) and Fisher (1939) noted a sequence of dominant features from primary, secondary and services in the course of development. Kuznet (1957) provided a historical perspective of modern economic growth based on developed countries. Kuznet stressed the existence of a common pattern of economic transformation. Other studies that used cross-country data also suggested a common pattern of change in economic structures (for example, Chenery & Syrquin 1986; Chenery & Taylor 1968; Chenery & Watanabe 1958; Syrquin 1988). Therefore, structural economic transformation is predictable in that most countries follow a similar sequence.

Identification of the predictable nature of an economic structure would be beneficial for understanding an economy. If the predictable component is identified, including in what sense this component exists, economic aggregates can be used to estimate it.

The implication of identifying the predictable component is that it allows researchers concentrate on estimating unpredictable components. Consequently, limited resources can be optimised by concentrating on the unpredictable component. In the study of input-output analysis, this approach will help considerably to reduce costs because the predictable cells can be estimated with aggregate measures.

Regression analysis was used to measure predictability. The criterion for determining the predictability of a cell was based on the adjusted R^2 of the regression analysis. The adjusted R^2 reflects the goodness of fit of the model. R^2 measures the variation in the dependent variable that can be explained by the independent variables. The adjusted R^2 also takes into account the number of independent variables including constant and the number of observations. Therefore, a higher value of adjusted R^2 reflects a better fit.

In addition, adjusted R^2 is more appropriate for comparing models if models have varying numbers of independent variables. Five functional forms are used in this study, one of which is a quadratic form. Therefore, as a measure of predictability, the adjusted R^2 is more reliable than R^2.

Choosing an appropriate level adjusted R^2 as the threshold for predictability creates a dilemma. If the threshold is relatively high to allow a better estimation, the number of cells that pass the threshold will be low. On the other hand, if the threshold is relatively low which causes less accurate estimation, the number of cells that pass the threshold will be high. However, in the current study, present author uses an adjusted $R^2 \geq 0.8$. However, the determination of the threshold is relatively subjective and depends on the analyst and the regions under study.

4.2. Stability

The term stability in the fundamental economic structure (FES) literature refers to *the degree to which certain elements are present across substantial samples* (Hewings, Sonis & Jensen 1988b, p. 164). This implies that these elements are always present across regions or nations regardless of their proportion of the economic structure. In other words, these components are inevitably present. The elements were the cells which lie on the secondary-tertiary and tertiary-tertiary. This terminology is similar to the concept underlying the minimum requirement approach developed by Ullman and Dacey (1960) in economic base theory.

The minimum requirement approach was designed to determine the share of urban employment structure required to support an urban area. An urban area needs employment to maintain services for its population. The minimum requirement approach is used to estimate employment in export activities (basic sector). Using this approach, the analyst can estimate employment in the basic sector by calculating any excess of the minimum requirement of employment in the non basic sectors in a region.

However, in the FES concept, it is likely that some elements of economic structure are inevitable-present in the whole economic structure. These elements are represented by cells formed in the interaction between the secondary-tertiary and tertiary-tertiary components of the input-output table because these cells have a relationship with economic aggregate measures (Jensen, West & Hewings 1988).

Parallel to this idea, the FES approach incorporates components that consistently exist across regions. These components therefore, are stable. However, in input-output analysis, the term stability is usually associated with structural change or technical change (Miller 1989). In the regional context, stability refers to a change in the direct requirement coefficients. However, McNicoll and Rees (1982) argued for two interpretations of stability: firstly, stability emphasised in the coefficients *per se;* and secondly, stability in the multipliers, that is, even though the input-output coefficients change, the multipliers are relatively stable. McNicoll and Rees (1982) noted only limited empirical evidence of stability at the regional level compared to the national level (eg. Beyers 1972, Conway 1975, 1977 at the regional level, and Carter 1970; Feldman, McClain & Palmer 1987; Gaiha 1980; Sawyer 1992; Sevaldson 1970 at the national level).

Usually, stability relates to inter-temporal changes in a region but this does not mean that stability does not have a spatial dimension. The stability of coefficients can be divided in two, i.e. *value* coefficients (current prices), and *volume* coefficients (constant prices). Tilanus (1966) argued that input-output coefficients in current prices were relatively more stable than those in constant prices. However, Sawyer (1992) found that the *value* coefficients (current price) were no more stable than the *volume* coefficients (constant price). Sawyer did not explore why his result contradicted with the previous study. It may be that the scope of Sawyer's study was much wider than that of Tilanus. In their study on small area tables, McNicoll and Rees (1982) found that input-output coefficients were relatively stable.

The stability concept in the FES emphasized the existence of a flow or part thereof in each cell. On the other hand, the stability concept in regard to input-output coefficient deals with variations in the coefficients. However, from the current research results showed similar patterns of stable cells for both concepts. The stable cells fall in the intersection formed of secondary-tertiary, tertiary-tertiary, and to a lesser extent, primary-tertiary parts of the table. The FES concept uses Boolean matrix algebra as a measure of stability because it counts only the existence of the flow. In comparison, the stability of the input-output coefficients is assessed by measuring variations in coefficients because the variation reflects the stability of the input-output coefficients. This study uses the coefficient of variation of input-output coefficients across regions.

The identification of stable components of the FES helps the analyst to separate the stable cells from the unstable cells. The objective of identifying stable cells is to determine an appropriate way of estimating these cells. The stable cells can be estimated using average coefficients of regional tables because these cells have a low variation. This study is justified of using the average coefficients.

The approach used to identify the stable cells is based on the coefficients of variation of the input-output coefficients across the regional tables. The threshold for the coefficients of variation is ≤ 0.5. However, applying this threshold is subjective.

4.3. Importance

The concept of importance in the FES is defined as *the degree to which the elements of the FES are part of a set of components of the economic structure which may be regarded as analytically important in the sense that change in these elements would likely create the most potential for the system-wide change* (Hewings, Sonis & Jensen 1988b, p. 164).

The term “ important coefficients” leads to two interpretations (Xu & Madden 1991). Firstly, coefficients are important in the sense that the cells significantly affect the formation of multipliers and gross output. This is the so-called inverse important parameter. Secondly, if the coefficients are the largest in their column, they are considered to be important. However, Jackson (1991) raised the issue of the relative importance between coefficients and transactions. Jackson tried to evaluate the relative importance between coefficients and transactions. The results indicated that the largest transactions are relatively more important than the largest coefficients. Obviously, transaction size is an important determinant of inverse sensitivity. Jackson argued that regional economic structure was represented most directly by the flow of goods and services. In addition, Jensen and West (1980) found that the largest coefficients were not necessarily important in the sense of affecting the multipliers. Even though it is likely that the largest coefficients tend to be important cells, the position of the cells in the input-output table contributes to the effect of the inverse important parameter.

The objective of identifying the important components is to estimate these components as accurately as possible because they affect the accuracy of the whole system. If these components can be identified, the remaining unimportant components can be estimated using other means because using less accurate estimation does not affect the whole system significantly. This leads to the optimal use of limited resources by concentrating on important cells only.

This study identifies important cells by assessing the impact on the output multipliers of a 10 per cent change in all coefficients simultaneously of the average regional tables. West (1982) developed this method to measure the sensitivity of the coefficients with respect to multiplier error. His method is similar to the work of Bullard and Sebald (1977). However, West’s method was better than that used by Bullard and Sebald (1977) because it considered the combined effect due to changes in all coefficients simultaneously. The cells are ranked according to their relative importance. The top 25 per cent of sensitive cells are deemed important in this procedure. Therefore, the cells that are classified as important are the top 25 per cent of sensitive cells. The reason for choosing a threshold of 25 per cent is that only the first 50 per cent of the cells affects the multipliers significantly (Jensen & West 1980) because only 50-60 per cent of the total cells are non zero cells in developing countries like Indonesia (21 sectors aggregation level). This means that 25 per cent of the total cells are approximately 50 per cent of non zero cells. Therefore, this threshold is justified.

The current study uses all three criteria properties, namely predictability, stability, and importance, and finds that approximately 85-90 per cent of all transaction cells in the initial intermediate transaction tables can be estimated using the FES approach or mechanical procedures. In addition, for 21 sectors aggregation, between 25-40 per cent of the cells are zero for regional tables in developing countries like Indonesia. This indicates that the estimation of regional input-output tables using the FES approach reduces cost considerably.

5. Sequence of the FES Procedures

The procedure for constructing a single region input-output table using the fundamental economic structure consists of three phases. The summary of the procedure is presented in Table 3 and Appendix Figure 1.

Phase I of the FES procedures comprise six steps. Phase I requires the availability of several regional tables to identify the FES. These regional tables are used to establish a prototype regional table. Therefore, the FES approach sequence begins with a set of regional tables. This phase also includes the calculation of the properties of the FES.

Phase II of the FES procedures consists of eleven steps. This phase deals with the estimation of the prototype intermediate transaction table.

Phase III of the FES procedures involves eight steps. The insertion of superior data is carried out in this phase.

5.1. Phase I: Identification of the FES based on Reference Tables

Step 1 involves the collection of regional tables to be used as reference tables. This step is very important because without a sufficient number of regional tables, it is difficult to identify the FES.

Step 2 checks the number of sectors and aggregation levels in the reference tables. Generally, each available regional table has a different number of sectors and different levels of aggregation. The process involves scrutiny of the sector classification. The objective of this process is to identify the ingredients of every sector. The results of this process can be used to determine an appropriate sector aggregation.

Step 3 adjusts the number of sectors by aggregating with other similar sectors if the number of sectors differs among tables. However, if the number of sectors are the same, the analysts can move directly to step 4. The aggregation process makes for conformity among regional tables in terms of sector aggregation.

Step 4 performs the regression analysis across the reference tables. The regression analysis uses the transaction cells of regional input-output tables as a dependent variable with various economic indicators, such as gross regional domestic product, total sectoral gross output and population as independent variables. The aim of this step is to identify the relationship between the transaction cells of the regional input-output tables and the economic indicators. The FES concept suggests that the transaction cells have a strong relationship with some economic indicators. This step is the identification of the predictable component of the FES.

Step 5 calculates the coefficients of variation of input-output coefficients across the reference tables. The aim of this step is to identify the stability of coefficient cells across the reference tables.

Step 6 runs a sensitivity analysis on the average regional reference table. The average regional table is a simple (unweighted) average of regional tables. The calculation is as follows:

$$A(X_{ij}) = \sum^{n} X_{ij}/n \qquad (4.1)$$

Where:

$A(X_{ij})$ = The average of transaction cells of regional input-output tables

X_{ij} = Transaction cells of each regional table

n = Number of regional tables

The reason for using a simple average is that the reference regional tables appear to provide a balanced representation of Indonesia’s regional economies with a wide range distribution between small, medium and large. A sensitivity analysis is used to identify the most sensitive cells. In this context, the sensitive cells are the important cells.

5.2. Phase II: Identification of FES Properties

Step 7 begins with the identification of predictable cells based on an adjusted R^2. This step constructs the intermediate prototype table. To establish the prototype table, analysts must decide the level of adjusted R^2 to be used as the threshold. Therefore, the prototype table consists of predicted transaction cells having an adjusted R^2 greater than the threshold. If the adjusted R^2 is set relatively high, the number of predicted transaction cells in the parent table appears to be low. However, the use of a high adjusted R^2 leads to a better estimation of transaction cells.

Step 8 calculates the transaction cells using the result of a regression estimation for the cells having the adjusted R^2 greater than the threshold of the adjusted R^2. The results of the estimation are sent to step 14.

Step 9 checks the stability of the unpredictable cells. The unpredictable cells that are below the threshold in step 8 identify the stability of these cells. The measure to identify the stable cells is the coefficients of variation (CV). The CV threshold is ≤ 0.5. For the stable cells that are lower than the threshold, the estimation uses the average coefficients of regional input-output coefficients. To make step 9 consistent with step 8, the coefficients' format is converted into a transaction format by multiplying the coefficients with the total sectoral gross output of respective columns for the region in question. The results of the estimation are used in step 14.

Step 10 identifies the most important cells that cannot be estimated by predictable and stable properties. This step is crucial for the final accuracy of the table. Identification in this step leads to improving the accuracy because the identified important cells use superior data. At the same time, the identification of important cells yields the unimportant cells simultaneously. The unimportant cells can use a less accurate estimation by means other than superior data because the cells are relatively unimportant to the whole system. Therefore, these unstable and unpredictable cells will be checked to determine whether these cells are important.

In this context, the unstable and unpredictable cells are checked using sensitivity analysis. The top 25 per cent of cells from this sensitive analysis, the most sensitive cells, are the most important cells. The reason for applying this threshold was discussed in section 4.4.3. The identified important cells go to step 13 for the collection of superior data. The estimation of identified unimportant cells uses average coefficients of regional input-output tables. The coefficients are then converted into transactions format by multiplying the coefficients with the total sectoral gross output from the respective column.

Table 3.
Procedure for Generating Single Regional Input-Output Tables: FES Approach

Phase I	**The Identification of FES based on Reference Tables**
Step 1	Collect several regional tables as the reference tables.
Step 2	Check the number of sectors and aggregation level among the reference tables.
Step 3	Adjust the number of sectors and aggregation level for conformity.
Step 4	Calculate the regression analysis across the reference tables.
Step 5	Calculate the coefficients of variation of input-output coefficients across the reference tables.
Step 6	Calculate sensitivity analysis applied to the average of the reference tables.
Phase II	**The Identification of FES properties**
Step 7	Check the predictable cells using the adjusted R^2 as the measurement.
Step 8	Estimate transaction cells if the adjusted R^2 is greater than the threshold and go to step 14.
Step 9	Check the stability of unpredictable cells.
Step 10	If the cells are less than the threshold, estimate these cells and go to step 14.
Step 11	Check important cells of unstable and unpredictable cells.
Step 12	If these cells are less than threshold, it means that these cells are unimportant, then estimate and go to step 14.
Phase III	**Derivation of Final Transaction Tables**
Step 13	Collect superior data for important cells (sensitive cells) in the intermediate quadrant.
Step 14	Derive prototype intermediate transaction cells by combining the results from steps 8, 10, 12 and 13.
Step 15	Collect superior data for final demand and primary input.
Step 16	Derive a prototype full transaction table by combining the results from steps 14 and 15.
Step 17	Reconcile and check for consistency.
Step 18	Refine this final hybrid table.
Step 19	Run sensitivity analysis to check the most sensitive cells in the final table.
Step 20	Check and reinsert superior data if needed to ensure accuracy.
Step 21	Calculate an inverse matrix and multipliers for the final transaction table.

5.3. Phase III: Derivation of Final Transaction Tables

Phase III has nine steps. This phase constructs the final transaction table. Step 13 collects superior data for intermediate cells. The superior data is needed to fill the identified important cells that cannot be estimated using the FES approach. These data go to step 14 to be supplemented with others data for constructing intermediate transaction cells.

Step 14 combines the results of steps 8, 10, 12, and 13 to construct prototype intermediate transaction cells.

Step 15 collects superior data for final demands and primary inputs. This final demand, especially household consumption, must be estimated as accurately as possible. Many researchers showed that households play an important role, especially in developing countries (Cochrane 1991; Hewings & Romanos 1981). In addition, household consumption patterns are always available at the province level in Indonesia, and even at the sub-province level, based on socio-economic surveys conducted by the country's Central Bureau of Statistics on a yearly basis. Government consumption patterns are also available based on government budgets at the province and sub-province levels. However, estimating government expenditure requires a lot of work.

Capital formation is one of the most difficult to estimate. However, the Office of Investment Coordination Board publishes investment data at the province level. In addition, the Office of the Department of Trade and Industry can provide some data that can be used for estimating capital formation at the province and sub-province level. The representative office of the Bank of Indonesia (the Central Bank) also publishes data that can be used to estimate the capital formation by sector. All these data from different sources can be used to ensure consistency. The change of stocks can be treated as a residual.

Exports and imports data are the most difficult to obtain. Exports and imports of food commodities can be estimated by using balance sheets of food commodities published by local governments on an annual basis. For other sectors, some data from the Office of the Department of Trade and Industry at the province and sub-province levels are also available for estimating exports. Some publication data from the representative office of the Bank of Indonesia (the Central Bank) contains exports data by sectors.

For the primary input quadrant, most sectors have labour expenditure data, therefore, estimating primary inputs is relatively easier. Other value added is treated as residual.

Step 16 combines the results of steps 14 and 15. This step derives the initial prototype transaction table.

Step 17 reconciles the prototype transaction table. In this step, reconciliation and checks are necessary for consistency because the table developed in the previous step is very coarse. The process involves balancing the column and row sums and using a modified RAS to reconcile other minor differences. A modified RAS is the process of RAS in which data assumed to be superior are "lock in". Only other data that are not known accurately are allowed to change. This step produces a final prototype transaction table.

Step 18 performs a sensitivity analysis to identify the most sensitive cells in the prototype table. This step carries out a sensitivity analysis to identify the most significant cells affecting the multipliers in the table. This step involves the scrutiny of the structure and features of the regional economy in question. If the result differs substantially from the analysts' expectations, in other words, if there is a suspicion of a significant error in some important cells, the following step must be carried out.

In step 20, the insertion of additional superior data is carried out to ensure accuracy if the previous step indicates a significant error. In this step, final checking, balancing and adjustment are necessary to complete the final table.

Step 21 calculates the inverse matrices and multipliers. The output income and employment multipliers are calculated for the final transactions table.

6. Performance of the FES approach

To evaluate the performance of the estimated tables using the FES approach, several comparisons based on overall matrix, overall output multipliers, provincial output and income multipliers have been employed. The evaluation methods are given in the Appendices. The comparison is carried out across provinces and every sector.

Jensen, West and Hewings (1988) developed the partitioned approach that is used to identify the regional economic structure. Regression analysis is used to identify the relationship between the regional transactions and the size of the regional economy. Three different measures of regional economic size are used: total sectoral gross output (TSGO); gross regional domestic products (GRDP) and population. The equations corresponding to each model follow:

The ***linear*** equation (Model A):

$$X_{ij}(r) = \alpha + \beta X(r); \qquad (1)$$

The ***linear logarithmic*** equation (Model B)

$$X_{ij}(r) = \alpha + \beta \log X(r); \tag{2}$$

The ***logarithmic linear*** equation (Model C)

$$\log X_{ij}(r) = \alpha + \beta X(r) \tag{3}$$

The ***double logarithmic*** equation (Model D)

$$\log X_{ij}(r) = \alpha + \beta \log X(r); \tag{4}$$

The ***quadratic*** equation (Model E)

$$X_{ij}(r) = \alpha + \beta_1 X(r) + \beta_2 X^2(r) \tag{5}$$

Where: X_{ij} (r) is the transactions entry for the *r*th region; X(r) is the independent variable for the *r*th region (total sectoral gross output, or population or total gross regional domestic products); m is the number of regions; k is the level of aggregation/number of sectors, r = 1 ....m, i,j = 1 ...k; α is a constant, and $\beta_{0,1,,2}$ are the coefficients of regression.

There are three tables which can be used to estimate prototype tables by using three indicators (population, total sectoral gross output and total gross regional domestic product). Selected functional forms of each cell for the estimation are based on the the highest adjusted R^2. Therefore, every table of each indicator may have different functional forms depending upon its adjusted R^2.

6.1. Overall Matrix Comparison

Using different independent variables, generally it appears that population as an independent variable performs much better than either gross regional domestic product or total sectoral gross output (the threshold of the adjusted $R^2 \geq 0.8$) in terms of the lower mean errors.

In most methods for evaluation, East Java (J) is the province with the lowest errors for all independent variables. There is no regular pattern of the performance among provinces such as whether or not the more diversified economy performs well. However, the most diversified province (East Java) appears to be the best for all methods of error measurement for all independent variables. It might be that the high interaction among economic sectors is reflected better in the model by independent variables which are in the aggregate form except for total sectoral gross output (TSGO) indicator. Population and gross domestic regional products (GDRP) are in the aggregate form, while total sectoral gross output (TSGO) is in the disaggregated form.

The error pattern can be seen in Figures 1 through 3. The figures show that the pattern of errors or deviation is relatively consistent when measured by several methods.

6.2. Overall Output Multiplier Comparison

The output multipliers of estimated tables are also compared with actual tables to see the deviation between cases and indicators. Most of the mean deviations for both type I and type II output multipliers are less than 10 per cent all independent variables (indicators) among provinces.

The population is the best independent variable (indicators) in terms of providing the lowest mean deviation of output multipliers.

Sector 18 (restaurant and hotel) and sector 11 (mineral manufacturing) have the highest proportion of errors for output multipliers for all independent variables (indicators). The patterns are consistent in that these sectors have the highest errors in most provinces for all independent variables. Restaurant and hotel sector does not only rely on local consumption, but also it relies on tourist consumption. Therefore, each province has a slightly different pattern depending upon visitors (domestic and foreign) to the province. Likewise, mineral manufacturing (sector 11) also depends on local resources which are not available in all provinces. Both these sectors can be considered as more region-specific. Therefore, the estimation of these sectors using either regression or average regional coefficients will distort the accuracy of the final model.

From these phenomena, it is suggested that sectors with a high dependency on local resources, region specific nature, and consumption from outside should use more reliable data (superior data). In the estimation, most of these sectors are estimated using either regression or average regional coefficients. Hence, these sectors have a relatively high error in output multipliers across the provinces. The result of the experiment supports the concern of many analysts that superior data or survey data is highly recommended for sectors with region specific or resource-based industries (Lahr 1993).

Figure 1

Error Pattern of Estimated Tables for GRDP

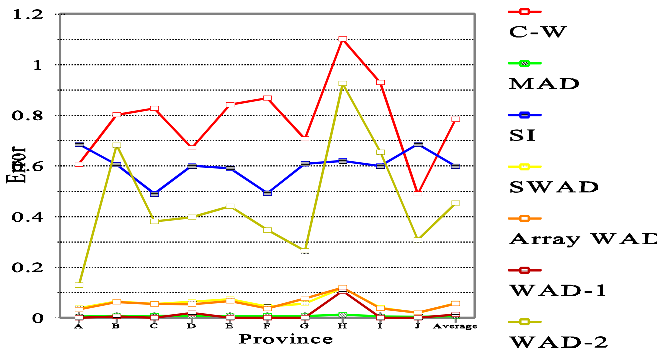


Figure 2

Error Pattern of Estimated Tables for Population

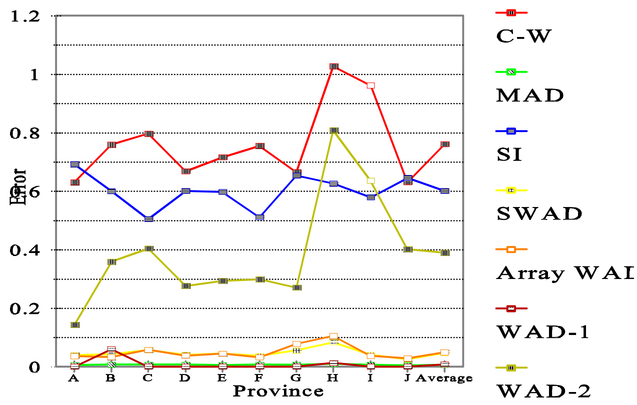
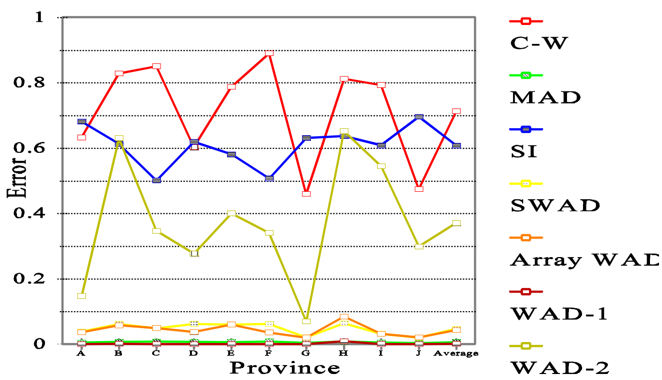


Figure 3

Error Pattern of Estimated Tables for TSGO



7. Summary and Conclusions

This paper describes the development of a horizontal approach to construct regional input-output tables based on the FES approach. The implementation of a previous FES approach developed by Van der Westhuizen (1992) was described. Some criticism of this approach was outlined and a revised FES approach is suggested.

The criteria and procedures of a horizontal approach have been established. The sequence of procedures is outlined. An initial requirement of the FES approach is the availability of several regional input-output tables. These tables are used as reference tables. Based on these reference tables, regression analysis is used to identify the FES. The results of regression analysis indicate the existence of the FES and the strength of a relationship between transaction flows and aggregate economic indicators.

The adjusted R^2 of the regression analysis is used to measure the predictability property of the FES. Stability property is measured by the coefficients of variation in the input-output coefficients across the reference tables, while a sensitivity analysis identifies the important cells.

Identification of the FES properties establishes the first approximation of the initial intermediate transaction cells. The estimation of the first approximation of transaction cells is based on the regression analysis results. If the cells do not meet this criterion, the stability of the cells must be checked. The stable cells can use the coefficients of the average regional tables. The unstable cells are checked using sensitivity analysis to determine whether these cells are important. If these cells are important, superior data is used for these cells. However, if these cells are unimportant, the coefficients of the average regional tables can be used.

The evaluation of the performance of the FES approach is measured by applying several statistical methods to provide some indications of the error patterns. The results of the evaluation using different tests appear to be consistent across provinces. In most cases, the errors are relatively low on average using different measures.

Using the above estimation/mechanical procedure, the analyst can construct a first approximation of regional input-output tables. This procedure can estimate approximately 85-90 per cent of non zero cells at 21 sectors aggregation in Indonesia. Only 10-15 per cent of non-zero cells need be estimated by superior data. This means that this procedure is relatively efficient. However, the weakness of the procedure is the requirement of several regional tables as reference tables.

References

Anselin, Luc. 1988, Model Validation in Spatial Econometrics: A Review and Evaluation of Alternative Approaches, **International Regional Science Review**, 11(3): 279-316.

Antille, G. 1990, Input-Output Tables and Scarcity of Data, **Economic Systems Research,** 2:147-155.

Baster, J. 1980, Stability of Trade Patterns in Regional Input-Output Tables, **Urban Studies,** 17(7):71-75.

Beyers, W.B. 1972, On the Stability of Regional Interindustry Models: The Washington Data for 1963 and 1967, **Journal of Regional Science**, 12(3): 363-374.

Beyers, W.B. 1976, Empirical Identification of Key Sectors: Some Further Evidence, **Environment and Planning A**, 8:231-236.

Billings, R.B. and Katz, J.L. 1982, A Technique to Obtain Accurate Impact Multipliers for Individual Firms by Means of Existing Input-Output Models, **Environment and Planning A,** Vol. 14. Pp. 739-744.

Biro Pusat Statistik. 1992, **Pendapatan Regional Propinsi-propinsi di Indonesia Menurut Lapangan Usaha** (Regional Income of Provinces in Indonesia by Industrial Origin 1983-1990).

Blake, C. and McDowall, S. 1967, A Local Input-Output Table, **Scottish Journal of Political Economy**, 14: 227-242.

Boomsma, P. and Oosterhaven, J. 1992, A Double Entry Method for the Construction Biregional Input Output Analysis, **Journal of Regional Science,** 32:269-284.

Braschler, C., Procter, M., and Kuehn, J.A. 1984, Comparison of Non-survey Input-Output Estimates Using Alternative Reduction Techniques, **Review of Regional Studies,** 14(1):22-33.

Brucker, S.M., Hastings, S.E., and Latham, W.R. 1990, The Variation of Estimated Impacts from Five Regional Input-Output Models, **International Regional Science Review,** 13:119-139.

Bullard III, C.W. and Sebald, A.V. 1977, Effects of Parametric Uncertainty and Technological Change on Input-Output Models, **Review of Economics and Statistics,** 59:75-81.

Bullard, C.W. and Sebald, A.V. 1988, Monte Carlo Sensitivity Analysis of Input-Output Models, **Review of Economics and Statistics,** 70:708-712.

Burford, R.L. and Katz, J.L. 1977, Regional Input-Output Multipliers Without A Full I-O Table, **Annals of Regional Sciences**, 11(3): 21-38.

Butterfield, Martin and Mules, Trevor. 1980, A Testing Routine for Evaluating Cell by Cell Accuracy in Short-cut Regional Input-output Tables, **Journal of Regional Science,** 20(3): 293-310.

Carter, A.P. 1970, **Structural Change in the American Economy**, Harvard University Press, Cambridge, MA.

Casler, S.D. and Hadlock, D. 1997, Contributions to Change in the Input-Output Model: The Search for Inverse Important Coefficients, **Journal of Regional Science,** 37(2):175-193.

Cella, G. 1996, Interindustry Linkages: Virtuous or Vicious? **Economic System Research,** 8(2): 145-159.

Chattergy, R., and Pooch, U.W. 1977, Integrated Design and Verification of Simulation Program, **Computer**, 10(4), 40-45.

Chenery, H.B. and Watanabe, T. 1958, International Comparisons of the Structure of Production, **Econometrica**, 26(4): 487-521.

Chenery, H.B., and Taylor, L. 1968, Development Patterns: Among Countries and Over Time, **The Review of Economics and Statistics**, 50(4): 391-415.

Chenery, H., and Syrquin, M. 1986, Typical Patterns of the Transformation, in Chenery, H., Robinson, S. and Syrquin, M. (Eds), **Industrialization and Growth**, Oxford University Press, New York.

Chenery, H., Robinson, S. and Syrquin, M. (Eds). 1986, **Industrialization and Growth**, Oxford University Press, New York.

Clark, C. 1940, **The Conditions of Economic Progress**, Macmilan, London.

Cochrane, S.G. 1991, Input-Output Linkages in a Frontier Region of Indonesia, **International Regional Science Review,** 13(1&2):183-203.

Conway, R.S. 1975, A Note on the Stability of Regional Interindustry Models, **Journal of Regional Science,** 15(1): 67-72.

Conway, R.S. 1977, The Stability of Regional Input-Output Multipliers, **Environment and Planning A,** 9: 197-214.

Craven, J. 1983, Input-Output Analysis and Technical Change, **Econometrica,** 51(3):585-598.

Cuello, F.A., 1994, **Regional Growth Theories and the Measurement of Regional Structural Change,** Unpublished Ph.D. Thesis, University of Illinois, Urbana Champaign.

Davis, H.C. 1976, Regional Sectoral Multipliers with Reduced Data Requirements, **International Regional Science Review,** 1(2): 18-29.

Deman, S. 1988, Stability of Supply Coefficients and Consistency of Supply-Driven and Demand-Driven, **Environment and Planning A,** 20:811-816

Deman, S. 1991, Stability of Supply Coefficients and Consistency of Supply-Driven and Demand-Driven: A Reply, **Environment and Planning A,** 23:1811-1817.

Deutsch, J. and Syrquin, M. 1989, Economic Development and the Structure of Production, **Economic Systems Research,** 1(4): 447-464.

Dewhurst, J.H.L. 1992, Using the RAS Technique as a Test of Hybrid Methods of Regional Input-Output Table, **Regional Studies,** 26(1):81-91.

Dewhurst, J.H.L. 1993, Decomposition of Changes in Input-Output Tables, **Economic Systems Research,** 5(1): 41-53.

Dietzenbacher, E. 1990, The Sensitivity of Input-Output Multipliers, **Journal of Regional Science,** 30(2): 239-258.

Drake, RL, 1976, A Shortcut to Estimate Regional I-O Multiplier: Methodology Evaluation. **International Regional Science Review,** 1(2): 1-17.

Duchin, F. 1988, Analysing Structural Change in the Economy, in Ciaschini, Maurizio (ed)**, Input Output Analysis: Current Developments,** Routledge Press, New York, :113-128.

Eskelinen, H. 1983, Findings on Input-Output in a Small Area Context, **The Annals of Regional Science**, 17(1): 40-55.

Feldman, S.J., McClain, D., and Palmer, K. 1987, Sources of Structural Change in the United States, 1963-78: An Input-Output Perspective, **Review of Economics and Statistics,** 69:503-510.

Fisher, Allan G.B. 1939, Production: Primary, Secondary and Tertiary, **Economic Record,** June: 24- 38.

Flegg, G. 1964. **Boolean Algebra and Its Application: Including Matrix Algebra**, Blackie, London.

Flegg, A.T. and Webber, C.D. 1997, On the Appropriate Use of Location Quotients in Generating Regional Input-Output Tables: Reply, **Regional Studies,** 31:795-805.

Gaiha, R. 1980, On Testing the Stability of Input-Output Relationships in the Indian Economy, **Journal of Development Economics,** 7:273-282.

Garhart, R., Jr. 1985, The Role of Error Structure in Simulations on Regional Input-Output Analysis, **Journal of Regional Science,** 25(3):353-366.

Garhart, R.E. and Giarratani, F. 1987, Nonsurvey Input-Output Estimation Techniques: Evidence on the Structure of Errors, **Journal of Regional Science,** 27(2): 245-253.

Gerking, S.D. 1976b, Reconciling “Rows Only” and “Columns Only” in an Input-Output Model, **International Regional Science Review**, 1(2):31-55.

Gerking, S.D. 1979a, Input-Output as a Simple Econometric Model: Reply, **Review of Economics and Statistics,** 61:623-626.

Gujarati, D. 1994, **Basic Econometrics**, Mc Graw Hill, Singapore.

Harigan, F. , McGilvray, J., and McNicoll, I. 1980, A Comparison of Regional and National Technical Structure, **The Economic Journal,** 90: 795-810.

Harmston, F., and Lund, L. 1967. **Application of An Input-Output Framework to a Community Economic System**, University of Missouri, Columbia.

Hewings, G.J.D. 1977, Evaluating the Possibilities for Exchanging Regional Input-Output Coefficients, **Environment and Planning A**, 9: 927-944.

Hewings, G.J.D. 1983, A Decomposition Approach to the Analysis of Changes in Regional Economic Structure, **Modeling and Simulation**, 14: 859-863.

Hewings, G.J.D., and Janson, B.N. 1980, Exchanging Regional Input-Output Coefficients: A Reply and Further Comments, **Environment and Planning A**, 12: 843-854.

Hewings, G.J.D. and Romanos, M.C. 1981, Simulating less Developed Region Under Limited Information, **Geographical Analysis**, 13(4): 373-390.

Hewings, G.J.D. and Jensen, R.C. 1988, Emerging Challenges in Regional Input-Output Analysis, **Annals of Regional Science,** 22:43-53.

Hewings, G.J.D., Jensen, R.C. and West, G.R. 1987, **Holistic Matrix Descriptor of Regional Input-Output Systems,** Working Papers in Economics. No. 60. Department of Economics, University of Queensland.

Hewings, G.J.D., Sonis, M. and Jensen, R.C. 1988a. Fields of Influence of Technological Change in Input-Output Models, **Papers Regional Science Association** 64 (1988) 25-36.

Hewings, G.J.D., Sonis, M., and Jensen, R.C. 1988b, Technical Innovation and Input-Output Analysis, in Nijkamp, P., Orishimo, I.,and Hewings, G.J.D., (eds), **Information Technology: Social and Spatial Perspective,** Springler-Verlag: 161-193

Jackson, R.W, Hewings, G.J.D. 1984, Structural Change in a Regional Economy: an Entropy Decomposition Approach, **Modeling and Simulation,** 15: 451-455.

Jackson, R.W. 1989, Probabilistic Input-Output Analysis: Modeling Directions, **Socio-Economic Planning Science,** 23(1-2): 87-95.

Jackson, R.W, Hewings, G.J.D., and Sonis, M. 1989, Decomposition Approaches to the Identification of Change in Regional Economies, **Economic Geography,** 65:217-231.

Jackson, R.W. 1991, The Relative Importance of Input Coefficients and Transactions in Input-Output Structure, in Dewhurst, J.H.L., Hewings, G.J.D., and Jensen, R.C. (eds), **Regional Economic Modeling: New Developments and Interpretations**. Avebury Sydney, Chapter 3: 51-65.

Jackson, R.W. Israilevich, P.R. and Comer, J.C. 1992, A Note on the Role of Survey Data and Expert Opinion in Constructing Input-Output Tables, **Papers in Regional Science,** 71(1): 87-93.

Jensen R.C. and West, G.R. 1980, The Effect of Relative Coefficient Size on Input-output Multipliers. **Environment and Planning A,** 12: 659-670.

Jensen, R.C. 1980, The Concept of Accuracy in Regional Input-Output Models, **International Regional Science Review,** 5(2):139-154.

Jensen, R.C., Hewings, G.J.D., Sonis, M., and West, G.R. 1988, On Taxonomy of Economies. **Australian Regional Economic Journal,** 2: 2-24.

Jensen, R.C., Mandeville, T.D. and Karunaratne, N.D. 1979. **Regional Economic Development: Generation of Regional Input-Output Analysis,** Croom Helm, London.

Jensen, R.C., West, G.R., Dewhurst, H.H.L. and Hewings. 1991, On the Concepts of Fundamental Economic Structure, in Dewhurst, J.H.L., Hewings, G.J.D., and Jensen, R.C. (eds), **Regional Economic Modeling: New Developments and Interpretations**. Avebury Sydney, Chapter 12: 228-293..

Jensen, R.C., West, G.R., and Hewings, G.J.D. 1988, The Study of Regional Economic Structure Using Input-Output Tables, **Regional Studies,** 22:209-220.

Jilek, J. 1971, The Selection of Most Important Input Coefficients, **Economic Bulletin for Europe,** 23(1): 86-105.

Katz, J.L. and Burford, R.L. 1987, Shortcut Multiplier Formulas for Interregional Input-Output Models, **Review of Regional Studies,** 17:31-45.

Knudsen, D.C., and Fotheringham, A.S. 1986, Matrix Comparison, Goodness of Fit, and Spatial Interaction Modeling, **International Regional Science Review,** 10(2):128-147.

Kuznet, S. 1957, Quantitave Aspect of the Economic Growth of Nations II. Industrial Distribution of National Product and Labour Force, **Economic Development and Cultural Change,** 5 (July): Supplement.

Lahr, M.L. 1992, **An Investigation into Methods for Producing Hybrid Regional Input-Output Tables (Hybrid Models),** Ph.D. Dissertation, University of Pennsylvania.

Lahr, Michael L. 1993, A Review of the Literature Supporting Hybrid Approach to Constructing Regional Input-output Models, **Economic Systems Research,** 5(3): 277-293.

McCarl, B.A., and Apland, J. 1986, Validation of Linear Programming Models, **Southern Journal of Agricultural Economics,** December: 155-164.

McNicoll, I.H. and Rees, J. 1982b, Intertemporal Stability in Small Area Input-Output Coefficients, **Scottish Journal of Political Economy,** 29:192-205.

Miller, R.E. 1989, Stability of Supply Coefficients and Consistency of Supply-Driven and Demand-Driven, **Environment and Planning A,** 21:1113-1120.

Miller, R.E. and Blair, P.D. 1985, **Input-Output Analysis: Foundations and Extension,** Prentice Hall, Engelwood Cliffs, New Jersey.

Naylor, T.H. and Finger, J.M. 1967, Verification of Computer Simulation Model, **Management Science**, 14 (92), pp. B12-B106.
Ostblom, G. 1992, Technological Change, Projection of the Technology Matrix and the Hypothesis of Negative, **Economic Systems Research,** 4:235-243.
Phibbs, Peter J. 1985, **Estimating Regional Input-Output Multipliers in Australia: a Methodological Study**, Ph.D. Thesis, University of New South Wales.
Powell, R.A. and Jensen, R.C. 1989, Regional Economic Structure: An Input-Output Approach, in Higgins, B. and Zagorsky, K (eds), 1989. **Australian Regional Development: Reading in Experiences , Policies and Prospect**. AGPS, Canberra A.C.T., Chapter 9: 173-195.
Schintke, J. and Staglin, R. 1984, Stability of Import Input Coefficients, in Smyshlyaev, A (ed), **Input Output Modeling: Proceedings of the Fifth IIASA., Lecture Notes in Economics and Mathematical Systems,** Springer-Verlag, Berlin: 129-139.
Schintke, J. and Staglin, R. 1988, Important Input Coefficients in Market Transaction Tables and Production Flow Tables, in Ciaschini, M. (Ed) 1988, **Input-Output Analysis: Current Developments**, International Studies in Economic Modeling series**,** Routledge, London and New York.
Schnabl, H. 1994, The Evolution of Production Structures, Analyzed by a Multi-layer Procedure, **Economic Systems Research,** 6(1):51-68.
Schnabl, H. 1995, The Subsystem--MFA: A Qualitative Method for Analyzing National Innovation Systems--The Case of Germany, **Economic Systems Research,** 7:383-396.
Sevaldson, P. 1970, The Stability of Input-Output Coefficients, in Carter, A.P. and Brody, A. (Eds), **Application of Input-Output Analysis,** Proceedings of the Fourth International Conference on Input-Output Techniques, Geneva, 8-12 January 1968, North Holland Publishing Company, Amsterdam, 10:207-237.
Sherman, J., and Morrison, W.J. 1950, Adjustment of an Inverse Matrix Corresponding to a Change in One Element of a Given Matrix, **Annals of Mathematical Statistics,** 21: 124-127.
Siebe, T. 1996, Important Intermediate Transactions and Multi-sectoral Modeling, **Economic Systems Research,** 8(2):183-193.
Simpson, D., and Tsukui, J. 1965, The Fundamental Structure of Input-Output Tables, An International Comparison, **The Review of Economics and Statistics,** , pp. 434-446.
Smith, Christine. 1983, **An Initial Exploration into an Alternative System for Small Economy Input-Output Table Construction**, Paper presented to the Input-Output Workshop of the 8th Meeting of The Regional Science Association (Australia & New Zealand Section), Armidale,30th November-2nd December, 1983.
Smith, Christine and Jensen, R.C. Without year. **A System for Generation of Small-Economy Input-output Tables**, Mimeo. Department of Economics, The University of Queensland.
Sonis, M. and Hewings, G.J.D. 1989, Error and Sensitivity Input-Output Analysis: A New Approach, in Miller, Ronald E., Polenske, K., and Rose, A.(eds), **Frontiers of Input-Output Analysis**, Oxford University Press, New York, Chapter 7: 232-244.
Syrquin, M. 1988, Patterns of Structural Change, in Chenery, H and Srinivasan, T.N. (eds), **Handbook of Development Economics,** Vol. 1. North Holland.
Syrquin, M. and Chenery, H. 1992, Three Decades of Industrialization, in Lal, Deepak (ed), **Development Economics,** Vol. I, An Elgar Reference Collection.

Szyrmer, J.M. 1992, Input-Output Coefficients and Multipliers from a Total-Flow Perspective, **Environment and Planning A,** 24:921-937.

Ullman, E.L., and Dacey, M.F. 1960, The Minimum Requirement Approach to Urban Economic Base, **Papers and Proceedings of the Regional Science Association,** 6:175-194.

Van der Westhuizen, J.M. 1992, **Towards Developing a Hybrid Method for Input-Output Table Compilation and Identifying a Fundamental Economic Structure (Regional Economics),** Ph.D. Dissertation. University of Pennsylvania.

Van der Westhuizen, M. 1997, Cell Properties as a Basis for Constructing Hybrid Regional Input-Output Tables, **Journal for Studies in Economics and Econometrics,** 21:45-68.

West G.R. 1981a. An Efficient Approach to the Estimation of Regional Input-output Multipliers, **Environment and Planning A,** 13: 857-867.

West, G.R. 1981b, **Generation of Regional Input-Output Tables (GRIT): An Introspection.** Department of Economics, University of Queensland, Working Paper No. 21. May 1981.

West, G.R. 1982, Sensitivity and Key Sector Analysis in Input-Output Models, **Australian Economic Papers,** 21:365-378.

West, Guy R. 1983, **Sensitivity and Probabilistic Analysis in Regional Input-Output Models**, Unpublished Ph.D. Thesis, Department of Economics, The University of Queensland.

West, G.R. 1990, Regional Trade Estimation: A Hybrid Approach, **International Regional Science Review,** 13:103-118.

West, Guy R. (1993), **Input-Output Analysis for Practioners version 7.1 User's Guide**.

West, G.R. 1997, **Structural Changes and Fundamental Economic Structures: The Case of Australia,** Paper presented to North American Meeting of the Regional Science Association International, Buffalo, New York, 5-9 November 1997.

West, G.R. 1998, **Structural Change and the Hollowing Out of the Queensland Economy, 1973-1992,** Paper presented at 22nd ANZRSAI Conference, Tanunda, South Australia, September 1998.

West, G.R., and Jensen, R.C. 1987. **Further Evidence to Support the Fundamental Economic Structure Hypothesis,** Paper to the 12th Annual Conference Australia nad New Zealand Section Regional Science Association, Geelong, December 1987.

West, G.R., and Jensen, R.C. 1993, **Development in Regional/Local Economic Modeling and Analysis: The Current Situation and the Likely Medium-term Future**, Paper to the Conference of the Australian and New Zealand Section of the Regional Science Association, Armidale, December 1993.

Xu, Songling and Madden, Moss. 1991, The Concept of Important Coefficients in Input-Output Models, in Dewhurst, J.H.L., Hewings, G.J.D., and Jensen, R.C. (eds), **Regional Economic Modeling: New Developments and Interpretations**. Avebury Sydney, Chapter 14: 66-95.

Appendices

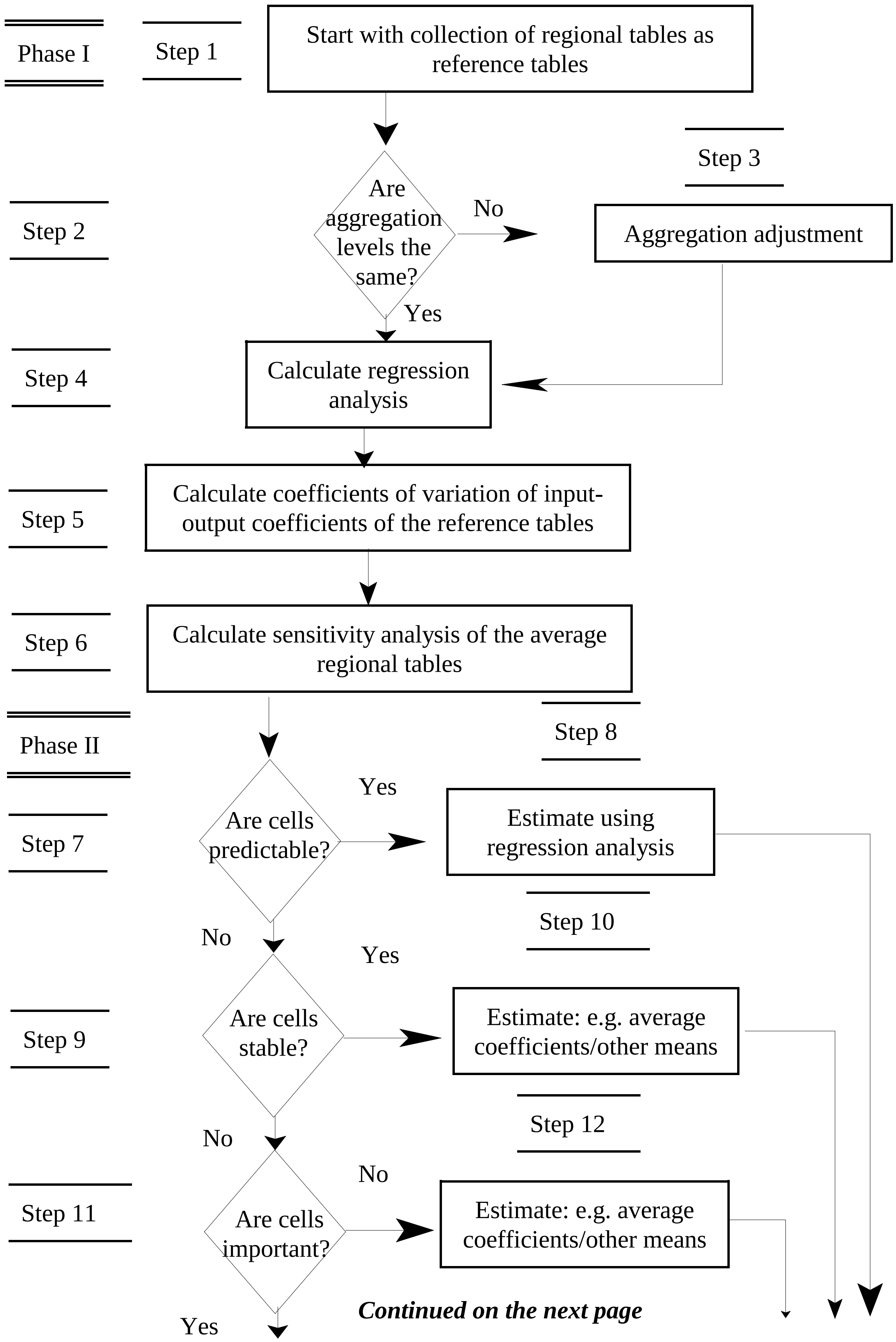
Table 1. Sectors Classification

1. Primary Sector	1. Paddy
	2. Other Food Crops
	3. Other Agriculture
	4. Livestock
	5. Forestry
	6. Fishery
	7. Other Mining
	8. Mineral Mining
	9. Oil Mining
2. Secondary Sector	10. Food Manufacturing
	11. Mineral Manufacturing
	12. Handicraft
	13. Other Manufacturing
	14. Oil and Gas Refinery
3. Tertiary Sector	15. Utilities
	16. Construction
	17. Trade
	18. Restaurant and Hotel
	19. Transp. & Communication
	20. Financial Inst. and Rent
	21. Services
HH1. Household Consumption Expenditure	
F2. Government Consumption Expenditure	
F3. Capital Formation	
F4. Change in stock	
F5. Export	
P1. Wages and Salaries	
P2. Other Value Added	
P3. Import	

Table 2. List of Reference Regional Input-Output Tables

No	Province	Year	Source	Number of sectors
1	West Nusa Tenggara (A)	1988	Office of Development Mineral Technology and Statistic	22
2	Irian Jaya (B)	1988	Office of Development Mineral Technology and Statistic	22
3	Yogyakarta (C)	1985	Office of Development Mineral Technology and Statistic	22
4	Maluku (D)	1988	Office of Development Mineral Technology and Statistic	22
5	Bali (E)	1985	Office of Development Mineral Technology and Statistic	22
6	Lampung (F)	1988	Office of Development Mineral Technology and Statistic	22
7	South Sulawesi (G)	1988	Office of Development Mineral Technology and Statistic	22
8	South Sumatera (H)	1988	Office of Development Mineral Technology and Statistic	22
9	West Java (I)	1983	Office of Development Mineral Technology and Statistic	22
10	East Java (J)	1988	Office of Development Mineral Technology and Statistic	22

Figure 1. Scheme of Hybrid Procedure using FES Approach



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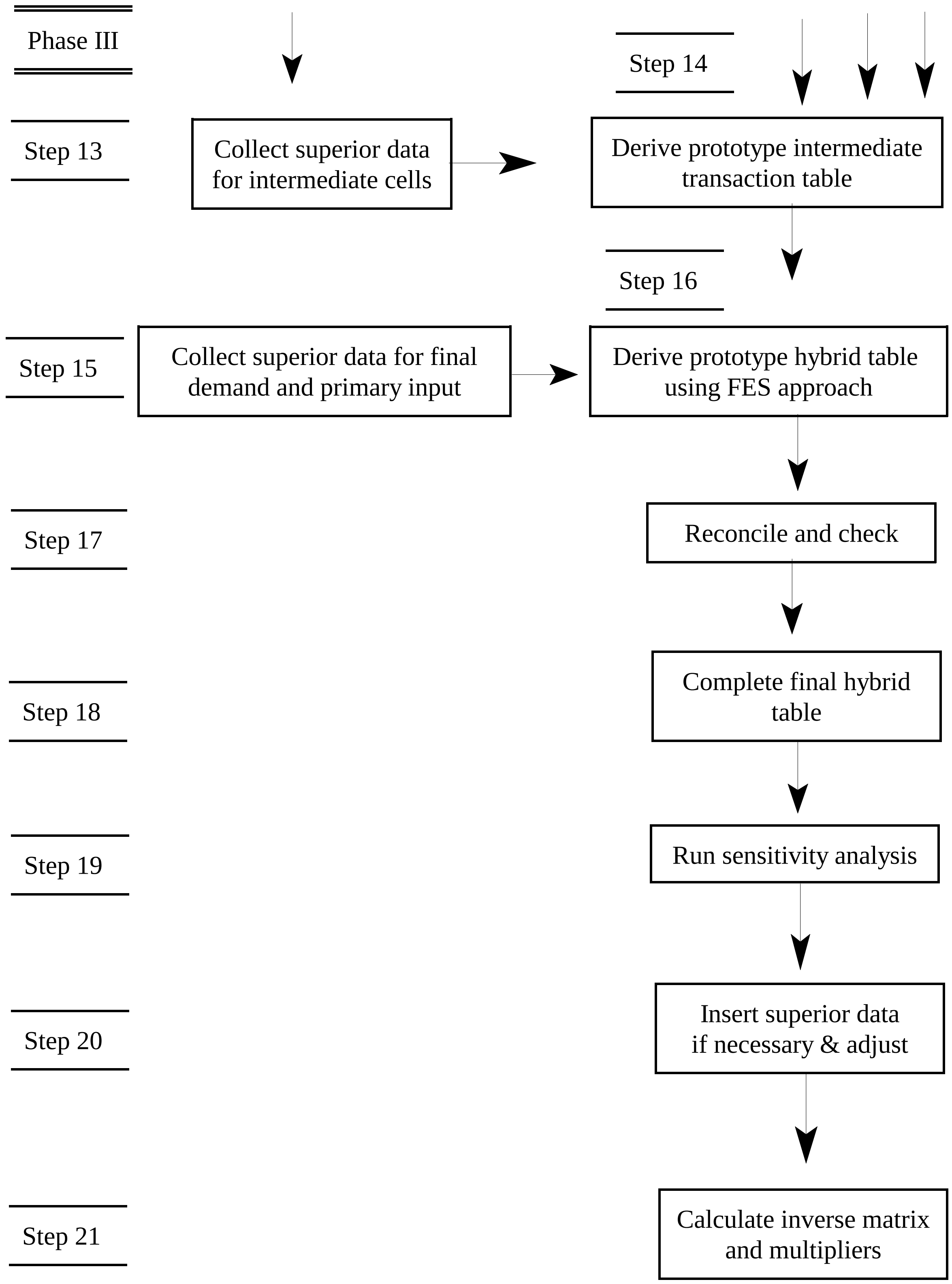
Phase III
Step 13
Collect superior data for intermediate cells
Step 14
Derive prototype intermediate transaction table
Step 16
Step 15
Collect superior data for final demand and primary input
Derive prototype hybrid table using FES approach
Step 17
Reconcile and check
Step 18
Complete final hybrid table
Step 19
Run sensitivity analysis
Step 20
Insert superior data if necessary & adjust
Step 21
Calculate inverse matrix and multipliers

Evaluation Methods

To measure the accuracy of the proposed FES method for constructing hybrid input-output tables, a number of measures can be used. As the benchmark, the actual regional tables will be used. Several methods will be employed to evaluate the error pattern, because every method has limitations. Therefore, the use of several methods enables a broader evaluation of the procedures. The following section is a short review of the methods that will be used in the evaluation of the FES approach. The following notation is used:

a_{ij} = Coefficients of actual regional table.

$\hat{a}_{ij}$ = Coefficients of estimated regional table.

MI = Actual Type 1 Output Multiplier

MII= Actual Type 2 Output Multiplier

$M\bar{I}$ = Estimated Type 1 Output Multiplier

$M\bar{I}\bar{I}$= Estimated Type 2 Output Multiplier

n = Number of sectors

6.1. Chenery and Watanabe's Method

Chenery and Watanabe (1958) used this method to compare international production structures. The input coefficients of two countries are compared. The summation of absolute differences in all the coefficients in each column is calculated. The result of this calculation is compared to the average total interindustry purchases of the industry as a ratio. This method also can be used to measure each row deviation as well. The more similar the production structure, the lower the ratio. The equation of this method is as follows:

$$C-W=\frac{\sum_i a_{ij}|a_{ij}-\hat{a}_{ij}|}{\frac{1}{2}\sum_i (a_{ij}+\hat{a}_{ij})} \quad (1)$$

6.2. Mean Absolute Deviation

This method is most widely used by analysts due to its simplicity. Morrison and Smith (1974) introduced this method to input-output analysis. However, Lahr (1992) pointed out that this measure has some caveats, such as there is no penalty for having errors in both high-valued and low valued coefficients. In addition, he stated that the magnitude of the measure changes with the number of sectors of the input-output tables that are evaluated. Therefore, Lahr (1992) proposed another method that will be discussed later. The mean absolute deviation is defined as:

$$MAD_j = \frac{\sum_{i}^{n} |a_{ij} - \hat{a}_{ij}|}{n} \quad (2)$$

This formula provides an indication of which sectors are not well estimated. A modification of MAD is to standardize the deviation relative to the size of a_{ij}. This formula will be discussed later as MAPE. The formula can be applied to rows, columns and whole tables.

6.3. Standardized Root Mean Squared Error

This method is to improve unstandardized root mean square error (RMSE). Knudsen and Fotheringham (1986) conducted an experiment on the usefulness of various statistics such as *information gain* statistic, *phi* statistic and *psi* statistic for comparing observed and predicted spatial interaction matrices. They concluded that SRMSE appears to be the most accurate. The equation is as follows:

$$SRMSE = \frac{[\sum_{i} \sum_{j} (a_{ij} - \hat{a}_{ij})^2 / (n^2)]^{0.5}}{\sum_{i} \sum_{j} a_{ij} / (n^2)} \quad (3)$$

6.4. Similarity Index

This method was developed by Isard and Romanoff (1968). This index is a modification of the Leontief index used by Schaffer and Chu (1969) in their study of Utah. The modification is needed to make the similarity index vary from zero to unity rather than from zero to two. This simplifies the previous scheme. In the present experiment, the mean similarity index was calculated by columns, rows, and for each matrix as a whole. The formula is as follows:

$$S_{ij} = 1 - \frac{|a_{ij} - \hat{a}_{ij}|}{(a_{ij} + \hat{a}_{ij})} \tag{4}$$

6.5. Mean Absolute Percentage Error

This formula is a modification of MAD. Butterfield and Mules (1980) proposed this method to measure the difference between two matrices. However, Butterfield and Mules (1980) noted that the formula becomes useless if a_{ij} is zero and $\hat{a}_{ij}$ is not. In addition, they also warned that any skewness of the distribution of errors will significantly affect the mean. The formula is as follows:

$$MAPE = \frac{1}{n^2} \sum_j \sum_i \left| \frac{a_{ij} - \hat{a}_{ij}}{a_{ij}} \right| \tag{5}$$

6.6. Standardized Weighted Absolute Deviation

Lahr (1992) first introduced this method to avoid the weakness of previous methods, emphasizing that this method was designed to solve problems inherent in most other measures. The formula for the standardized weighted absolute deviation is:

$$SWAD = \frac{\sum_j \sum_i (a_{ij} + \hat{a}_{ij}) |a_{ij} - \hat{a}_{ij}|}{\sum_j \sum_i (a_{ij} + \hat{a}_{ij})} \tag{6}$$

This measure uses (a_{ij} + $\hat{a}_{ij}$) as the weight for the absolute difference. Therefore, the errors of large cells are enhanced. By using this method, large cells are taken into account. He also proposed another formula if the array assignment is a critical issue. The equation is as follows:

$$ArrayWAD = \frac{\sum_j \sum_i a_{ij} |a_{ij} - \hat{a}_{ij}|}{\sum_j \sum_i a_{ij}} \tag{7}$$

However, these previous methods do not take into account the proportional error like other methods such as MAPE. Therefore, Lahr modified the formula as follows:

$$WAD1 = \frac{(\sum_j \sum_i a_{ij}) \sum_j \sum_i (a_{ij} + \hat{a}_{ij}) |a_{ij} - \hat{a}_{ij}|}{(\sum_j \sum_i a_{ij}^2)[\sum_j \sum_i (a_{ij} + \hat{a}_{ij})]} \qquad (8)$$

If there is a 100 per cent error situation when all $\hat{a}_{ij}$ are zero, the following equation will be used:

$$WAD2 = \frac{\sum_j \sum_i a_{ij} |a_{ij} - \hat{a}_{ij}|}{\sum_j \sum_i a_{ij}^2} \qquad (9)$$

Table 3

Accuracy Test of Coefficient Matrices for GRDP

Province	C-W	MAD	SRMSE	SI	MAPE	SWAD	Array WAD	WAD-1	WAD-2	MAPE M1	MAPE M2
A	0.60641	0.00529	2.33512	0.68490	4.71363	0.03836	0.03234	0.00024	0.12919	0.05774	0.05697
B	0.80152	0.00728	3.03173	0.60500	16.52856	0.06491	0.06235	0.00570	0.68195	0.08049	0.08556
C	0.82684	0.00764	2.91797	0.48903	28.25605	0.05480	0.05431	0.00016	0.38045	0.10800	0.11439
D	0.67110	0.00761	2.23580	0.60025	15.24423	0.06267	0.05322	0.01827	0.39703	0.06171	0.07853
E	0.84162	0.00684	3.52692	0.59098	8.82344	0.07398	0.06619	0.00006	0.43974	0.07750	0.08163
F	0.86671	0.00812	2.73744	0.49246	15.78217	0.04455	0.03675	0.00018	0.34580	0.09001	0.09245
G	0.70676	0.00679	2.87706	0.60789	7.10179	0.05603	0.07603	0.00001	0.26456	0.06332	0.06232
H	1.10150	0.01215	4.21902	0.61937	1.63176	0.11706	0.11991	0.10491	0.92513	0.11503	0.11373
I	0.92926	0.00564	3.01460	0.59922	86.51160	0.03936	0.03737	0.00009	0.65456	0.06424	0.06599
J	0.48998	0.00364	1.77973	0.68466	1.81597	0.01963	0.02129	0.00024	0.30809	0.03626	0.04213
Average	0.78417	0.00710	2.86754	0.59738	18.64092	0.05713	0.05598	0.01299	0.45265	0.07543	0.07937

Note: MAPE M1= MAPE Multiplier Type 1, MAPE M2= MAPE Multiplier Type 2. Other methods are applied for the coefficients of the table.

Table 4

Accuracy Test of Coefficient Matrices for Population

Province	C-W	MAD	SRMSE	SI	MAPE	SWAD	Array WAD	WAD-1	WAD-2	MAPE M1	MAPE M2
A	0.63054	0.00538	2.66279	0.69204	5.03797	0.03852	0.03569	0.00014	0.14257	0.04499	0.05258
B	0.75920	0.00665	2.43555	0.59983	19.44726	0.04241	0.03280	0.06027	0.35871	0.04396	0.04326
C	0.79580	0.00730	3.03444	0.50443	32.97875	0.05648	0.05771	0.00001	0.40426	0.07989	0.08578
D	0.66741	0.00714	2.07916	0.60073	16.64550	0.04038	0.03697	0.00002	0.27578	0.05098	0.04045
E	0.71548	0.00552	2.77172	0.59806	9.22102	0.04417	0.04415	0.00009	0.29333	0.05342	0.05769
F	0.75507	0.00705	2.18427	0.51098	79.32416	0.03615	0.03169	0.00017	0.29823	0.06699	0.06821
G	0.66532	0.00641	2.72470	0.65344	6.47007	0.05466	0.07771	0.00012	0.27039	0.06143	0.06103
H	1.02732	0.00920	3.36703	0.62569	0.97506	0.08329	0.10480	0.01228	0.80851	0.10441	0.12210
I	0.96127	0.00587	3.16638	0.57940	83.61780	0.04039	0.03631	0.00026	0.63600	0.05326	0.05214
J	0.62987	0.00432	1.82861	0.64540	2.19079	0.02506	0.02776	0.00034	0.40169	0.05045	0.05875
Average	0.76073	0.00649	2.62547	0.60100	25.59084	0.04615	0.04856	0.00737	0.38895	0.06098	0.06420

Note: MAPE M1= MAPE Multiplier Type 1, MAPE M2= MAPE Multiplier Type 2. Other methods are applied for the coefficients of the table

Table 5

Accuracy Test of Coefficient Matrices for TSGO

Province	C-W	MAD	SRMSE	SI	MAPE	SWAD	Array WAD	WAD-1	WAD-2	MAPE M1	MAPE M2
A	0.63268	0.00552	2.48841	0.68126	4.28329	0.03878	0.03683	0.00010	0.14712	0.05681	0.06205
B	0.82878	0.00745	3.15819	0.61233	17.86587	0.06190	0.05764	0.00109	0.63037	0.06152	0.06370
C	0.85065	0.00806	3.06552	0.50066	33.39917	0.04838	0.04948	0.00020	0.34661	0.10948	0.11374
D	0.60335	0.00696	2.62017	0.61957	15.40676	0.06248	0.03722	0.00020	0.27766	0.07026	0.08866
E	0.78784	0.00644	3.21248	0.58130	7.79703	0.05983	0.06032	0.00006	0.40073	0.06848	0.07133
F	0.89047	0.00868	3.38536	0.50772	19.95470	0.06153	0.03620	0.00009	0.34068	0.08394	0.08624
G	0.45974	0.00475	1.35365	0.63161	5.43427	0.02120	0.02003	0.00026	0.06969	0.04649	0.04424
H	0.81237	0.00763	3.10646	0.63733	1.01610	0.06337	0.08465	0.00931	0.65304	0.07865	0.08946
I	0.79320	0.00492	2.40733	0.60861	69.73507	0.03191	0.03111	0.00039	0.54485	0.05671	0.05786
J	0.47466	0.00351	1.54399	0.69536	2.43098	0.01939	0.02064	0.00028	0.29866	0.03201	0.03573
Average	0.71338	0.00639	2.63416	0.60758	17.73232	0.04688	0.04341	0.00120	0.37094	0.06643	0.07130

Note: MAPE M1= MAPE Multiplier Type 1, MAPE M2= MAPE Multiplier Type 2. Other methods are applied for the coefficients of the table.