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Goodness Test of Adaptability to Model of Technical Changes and Test of Forecasting Accuracy

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Abstract

The technical coefficient input-output (X_{ij}) as an element of the technical coefficient matrix (A) is estimated to have good forecasts for the next several periods $(n+1)$. By substituting the final demand (F) for the period $(n+1)$ into the Input Output (IO) model in the equation $X=(I-A)^{-1}F$ the total output (X) for the period $(n+1)$ will be obtained from the forecasting results. The total output of forecasting results (X^*) is then compared with the actual total output to see the magnitude of the deviation. In the regression equation, the coefficient of determination (R^2) is a measure of "goodness of fit" which states how well the regression line explains the independent variable with the dependent variable. The test is carried out by regressing the technical coefficient of input-output in the year $(n+1)$ against the technical coefficient in the nth year in a simple linear regression equation $X_{ij}^*=\alpha+\beta X_{ij}$. This test was conducted to see the validity of the technical coefficients in forecasting the IO model. This research is an empirical study that uses data from the Jambi Province Input Output Tables in 1998, 2007 and 2016, each of which has been collected in a common set to see the comparability between observation periods. The results show that the technical change model is quite well used for forecasting according to the assumption that the technical coefficient level is constant during the planning period. Meanwhile, the estimated output deviation tends to be higher than that of the actual data.

1. INTRODUCTION

Although the national economy is formed from regional economies, input-output (IO) analysis at the regional level is important, given the characteristics and features of a regional economy may differ from the characteristics of the national economy. The smaller the economy, the greater its dependence on exogenous factors from outside the economy.

The preparation of the IO table is not an easy job, it requires an extraordinarily complex database involving various considerations regarding data (data judgment) [9]. In May 2021 the Central Statistics Agency (BPS) has just released the 2016 IO table for each province in Indonesia in line with the completion of the preparation of the 2016 national Inter Regional Input Output (IRIO) table [3]. The IO table can be used for fsorecasting. The economic output for several future periods can be estimated using the operational matrix derived from IO table. This study aims to utilize the regional IO data series as material for empirical studies testing forecasting accuracy with the IO model [1].

2. DATA AND METHOD

This study uses IO table data for Jambi Province in 1998, 2007 and 2016, each of which has been uniformly aggregated to see comparability between observation periods. The 1998 Jambi Province IO table consisted of 60 sectors, while the 2007 IO table consisted of 70 sectors. The latest IO data released by BPS in May 2021 is the 2016 IO table which is arranged in 52 sector dimensions and 17 industry categories. Uniform aggregation (common set) produces a series of IO tables in 14 sector dimensions for each year of observation. The scope of the study is empirical in nature and is limited to the use of domestic transaction data on the basis of producer prices. The IO table was first introduced by W. Leontief in the 1930s. IO table is a table that presents information about transactions of goods and services that occur between production sectors in an economy in the form of a matrix.

Table 1. Simplification of the Input-Output Table

Seller Sector	**Buyer Sector**				**Final Consumption**	**Total Outputs**
	1	**2**	**...**	***n***		
1	x_{11}	x_{12}	...	x_{1n}	f_1	X_1
2	x_{21}	x_{22}	...	x_{2n}	f_2	X_2
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
n	x_{n1}	x_{n2}	...	x_{nn}	f_n	X_n
Value-added	v_1	v_2	...	v_n		
Import	m_1	m_2	...	m_n		
Total Inputs	X_1	X_2	...	X_n		

Source: [4]

From the IO simplification in Table 1, two balanced balance equations can be made in terms of rows and columns:

$$\sum_{j=1}^{n} x_{ij} + f_i = X_i \quad \forall i = 1,\ldots,n \tag{1}$$

$$f\sum_{i=1}^{n} x_{ij} + v_j + m_j = X_j \quad \forall j = 1,\ldots,n \tag{2}$$

where x_{ij} is the value of the flow of goods or services from sector-*i* to sector-*j*; f_i is total final consumption (final demand); v_j is value added and m_j is import. The definition of a balanced balance is that the total output equals the total input [5].

The flow of transactions between sectors in the first quadrant in IO table can be transformed into coefficients by assuming that the amount of various purchases is fixed for a level of total output and there is no possibility of substitution of one raw material input with another raw material input. Mathematically, these coefficients can be written as follows [2]:

$$a_{ij} = x_{ij} / X_j \tag{3}$$

$$x_{ij} = a_{ij} X_j \tag{4}$$

By combining the previous equations, we obtain [8]:

$$\sum_{j=1}^{n} a_{ij} X_j + f_i = X_i \quad \forall i = 1,\ldots,n \tag{5}$$

or in matrix notation it can be written as follows:

$$AX + f = X \tag{6}$$

where:

$$a_{ij} \in A_{n\times n};\ f_i \in f_{n\times 1};\ \text{and } X_i \in X_{n\times 1}$$

by manipulating the above equation we obtain:

$$(I - A) - 1\,F\ =\ X \tag{7}$$

Equation (7) is the basic relationship between Table IO and $(I - A) - 1$ which is commonly referred to as the Leontief inverse matrix. This matrix contains important information about how the increase in production from one sector will lead to the development of other sectors. Leontief's inverse matrix encapsulates the whole impact of a change in a sector's production on the total production of other sectors which translated into coefficients called multipliers.

The input-output technical coefficient (X_{ij}) as an element of the technical coefficient matrix (A) is thought to have forecasting power for several future periods $(n+1)$. By substituting the final demand data (F) for the period $(n+1)$ into the IO model in the equation $X = (I - A)^{-1}F$, the total output data (X) for the period $(n+1)$ forecast results will be obtained. The forecasted total output data (X^{*}) is then compared with the actual total output data to see the magnitude of the deviation.

The coefficient of determination (R^2) is a measure of the goodness of fit of the regression equation which states how well the sample regression line matches the data [7]. In other words, the coefficient of determination is a measure that measures the goodness of a regression equation model, whether the model is good enough to explain the independent variable with the dependent variable. The test is carried out by regressing the technical coefficients of the input-output year $(n+1)$ to the technical coefficients of the nth year in a simple linear regression equation as follows:

$$X_{ij}^{*} = \alpha + \beta X_{ij}. \tag{8}$$

In measuring the goodness of fit of a regression equation, the coefficient of determination provides the percentage proportion of the total variation in the dependent variable described by the regression model. The value ranges from 0 (zero) to 1 (one) or $0 < R^2 < 1$ [10]. Coefficient values close to zero mean that the ability of the independent variables to explain the dependent variable is very limited. A coefficient value close to one means that the independent variables provide almost all the information needed to provide a variety of dependent variables.

$$R^2 = \frac{SSR}{SST} \times 100\% \tag{9}$$

where SSR is the sum of squares of regression and SST is the sum of squares total.

The output multiplier matrix (Multiplier Product Matrix) is used to see the impact of a sector as a whole in an economy, capturing the influence of a sector based on backward and forward linkages and at the same time being able to explain the relationship between a sector and other sectors [6].

$$MPM = \tfrac{1}{V}\left\| b_{i.} b_{.j} \right\| = \tfrac{1}{V}\begin{pmatrix} b_{1.} \\ b_{2.} \\ . \\ . \\ b_{n.} \end{pmatrix}\begin{pmatrix} b_{.1} & b_{.2} & \dots & b_{.n} \end{pmatrix} \tag{10}$$

where:

$$\mathrm{V} = \sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij} \tag{11}$$

$b_{i.}$ = the sum of all the columns in the *i*-row of the Leontief inverse matrix, or often used to measure the amount of forward linkage.

$b_{.j}$ = the sum of all the rows in the *j*-column of the Leontief matrix inverse, or often used to measure backward linkage.

3. RESULTS AND DISCUSSION

BPS displays IO data in the dimensions of 17 business field categories similar to the display of Gross Domestic Product (GDP) data which is usually released quarterly. IO table of Jambi Province in 1998, 2007 and 2016 after being aggregated according to research objectives is classified into 14 (fourteen) sectors as follows:

Table 2. Sector Classification Table IO Jambi Province

Category (17)	Sector (14)		Description
	No	Name	
A	1	A	Agriculture, Forestry and Fisheries
B	2	B	Mining and excavation
C	3	C	Processing industry
D E	4	DE	Procurement of Electricity, Gas and Water and Waste, Waste and Recycling Management
F	5	F	Construction
G	6	G	Wholesale and Retail Trade; Car and Motorcycle Repair
H	7	H	Transportation and Warehousing
I	8	I	Provision of Accommodation and Food and Drink
J	9	J	Information and Communication
K	10	K	Financial Services and Insurance
L MN	11	LMN	Real Estate and Corporate Services
O	12	O	Government Administration, Defense and Compulsory Social Security
P Q	13	PQ	Education Services, Health Services and Social Activities
RSTU	14	RSTU	Other Services

Source: Jambi Province IO table, processed

The 2007 input coefficient which is regressed against the 1998 input coefficient produces a coefficient of determination (R-square) that is significant at the 5 percent significance level for the primary sector and the secondary sector other than "Construction (F)", but not significant for the tertiary sectors except in the sector “Transportation and Warehousing (H)”, “Provision of Accommodation and Food and Drink (I)”, and “Financial Services and Insurance (K)”.

Meanwhile, the 2016 input coefficient which was regressed against the 2007 input coefficient results in more significant values of the coefficient of determination (R-square) at the 5 percent significance level. Apart from being seen in the primary and secondary sectors, significance is also seen in the tertiary sectors which are the same as the previous regression output (H, I and K) and in the "Other Services (O)" sector.

Table 3. R-square Value, α and β in 2007

Sector	R-square	Significance F		α			β		
				coefficients	P value		coefficients	P value	
A	0,87681514	0,00000083	*	0,00051338	0,86592938	ns	1,93253553	0,00000083	*
B	0,61316659	0,00092621	*	0,00043769	0,04981729	*	0,08933002	0,00092621	*
C	0,84844068	0,00000293	*	0,00712973	0,12456681	ns	0,37511781	0,00000293	*
DE	0,53197969	0,00307359	*	0,00247450	0,73538356	ns	0,67763224	0,00307359	*
F	0,12885737	0,20751156	ns	0,00339764	0,43495570	ns	0,10867408	0,20751156	ns
G	0,00095357	0,91653989	ns	0,02277832	0,17015481	ns	0,10459881	0,91653989	ns
H	0,91599905	0,00000008	*	0,00170466	0,35937681	ns	1,11980096	0,00000008	*
I	0,56237145	0,00200991	*	0,00689111	0,43665016	ns	0,47930197	0,00200991	*

J	0,00015625	0,96617067	ns	0,01741443	0,13048364	ns	-0,02595929	0,96617067	ns
K	0,43617096	0,01014469	*	-0,00350952	0,69254336	ns	1,42169131	0,01014469	*
LMN	0,02146351	0,61723555	ns	0,01438182	0,07426794	ns	0,28235409	0,61723555	ns
O	0,26985579	0,05693794	ns	0,00031874	0,01818853	*	0,00604897	0,05693794	ns
PQ	0,03928364	0,49698198	ns	0,01229437	0,02935891	*	0,25889408	0,49698198	ns
RSTU	0,08639900	0,30771161	ns	0,00489056	0,08571231	ns	0,20871915	0,30771161	ns

Source: 2007 regression outputs

Regression models as such have high R-square values or in other words the previous period's technical coefficient (X_{ij}) is able to explain the next period's technical coefficient (X^*_{ij}). There were no significant technical changes from one period to the next, as indicated by the results of the regression test of the technical coefficients $(X^*_{ij}) = \alpha + \beta X_{ij}$ with the hypotheses $\alpha = 0$ and $\beta = 1$. The R-square, α and β values as referred to are presented in Tables 3 and 4.

Table 4. R-square Value, α and β in 2016

Sector	R-square	Significance F		α			β		
				coefficients	P value		coefficients	P value	
A	0,85129412	0,00000261	*	0,00097059	0,52478414	ns	0,42269136	0,00000261	*
B	0,71621405	0,00013555	*	-0,00176798	0,69951161	ns	18,78266059	0,00013555	*
C	0,78305629	0,00002608	*	-0,00843952	0,48040834	ns	1,85527914	0,00002608	*
DE	0,75505447	0,00005484	*	-0,00724227	0,69392767	ns	3,13100179	0,00005484	*
F	0,82324952	0,00000747	*	0,01136326	0,00915783	*	1,85908423	0,00000747	*
G	0,19643629	0,11245430	ns	0,01342870	0,00765993	*	0,14504999	0,11245430	ns
H	0,54470494	0,00258094	*	0,00300716	0,75562890	ns	1,61952718	0,00258094	*
I	0,43309112	0,01050995	*	0,00475003	0,68818829	ns	0,76816427	0,01050995	*
J	0,00147858	0,89616434	ns	0,01871655	0,24621907	ns	0,06392649	0,89616434	ns
K	0,48811288	0,00544092	*	0,00503179	0,12713410	ns	0,32504887	0,00544092	*
LMN	0,05589311	0,41578692	ns	0,01278887	0,10001697	ns	0,24174184	0,41578692	ns
O	0,28379044	0,04984319	*	0,00776922	0,20741017	ns	21,11452794	0,04984319	*
PQ	0,08749519	0,30451856	ns	0,00915834	0,05215880	ns	0,22690789	0,30451856	ns
RSTU	0,21150319	0,09801046	ns	0,00909421	0,03488515	*	0,72420757	0,09801046	ns

Sumber: 2016 regression outputs

Forecasting accuracy is done by testing the deviation of the estimated sectoral output value with actual data. The test was carried out twice using Leontief's inverse matrices in 1998 and 2007.

Table 5. Output Deviation in 2007

Sector	Final Demand (F)	Output *(X)*		Deviation	
		Estimation	Actual	Million Rp	%
A	7.192.553,86	13.713.094,71	10.595.652,50	3.117.442,22	29,42
B	7.856.216,12	8.776.768,49	8.181.480,75	595.287,74	7,28
C	13.656.012,63	16.260.010,61	16.201.064,64	58.945,97	0,36
DE	1.287.529,68	1.638.731,12	1.796.039,09	- 157.307,97	- 8,76
F	5.645.629,56	5.985.969,78	5.942.351,61	43.618,17	0,73
G	2.737.413,33	5.851.974,91	3.671.951,08	2.180.023,83	59,37
H	3.593.547,14	5.285.452,31	4.819.441,23	466.011,07	9,67
I	1.634.750,87	1.943.203,27	1.848.568,53	94.634,74	5,12
J	281.948,84	440.874,45	472.753,26	- 31.878,80	- 6,74
K	444.548,51	738.035,08	1.876.598,37	- 1.138.563,29	- 60,67
LMN	425.580,89	1.117.994,41	1.065.624,04	52.370,37	4,91
O	3.084.755,00	3.084.755,00	3.102.603,56	- 17.848,56	- 0,58
PQ	1.059.962,44	1.123.543,61	1.111.994,54	11.549,07	1,04
RSTU	793.855,36	1.036.762,33	1.141.946,79	- 105.184,46	- 9,21
Total	**49.694.613,23**	**66.997.770,07**	**61.828.669,99**	**5.169.100,07**	**8,36**

Source: processed data

The deviation of the estimated total output using the Leontief 1998 matrix test has a tendency to be overestimated, while the 2007 Leontief matrix test tends to underestimated. The total estimated value of output for 2007 is higher than the actual data with a deviation of 8.36 percent. The value of the deviation varies between sectors, there are even underestimated sector deviations. The deviation of the estimated total output data for 2016 is minus 8.9 percent, or smaller than the actual total output value. The value of the deviation broken down by sector is also mostly negative.

Table 6. Output Deviation in 2016

Sector	Final Demand (F)	Output (*X*)		Deviation	
		Estimation	Actual	Million Rp	%
A	24.099.532,77	36.559.318,66	44.710.216,21	- 8.150.897,55	- 18,23
B	23.121.998,96	24.253.826,59	27.927.498,17	- 3.673.671,58	- 13,15
C	50.596.627,86	59.839.523,47	59.851.449,42	- 11.925,95	- 0,02
DE	2.819.372,16	4.776.823,21	9.582.729,06	- 4.805.905,85	- 50,15
F	14.647.317,87	15.857.472,71	16.328.416,36	- 470.943,65	- 2,88
G	19.848.519,28	23.100.483,30	28.164.157,82	- 5.063.674,52	- 17,98
H	8.192.042,51	12.759.691,80	14.254.606,85	- 1.494.915,05	- 10,49
I	5.521.457,99	6.545.775,50	6.656.038,13	- 110.262,63	- 1,66
J	4.074.242,64	5.000.543,45	8.502.440,37	- 3.501.896,92	- 41,19
K	2.427.276,12	10.253.720,66	4.882.304,55	5.371.416,11	110,02
LMN	5.206.758,34	8.475.714,99	9.474.778,77	- 999.063,78	- 10,54
O	8.259.056,48	8.342.220,39	8.752.300,68	- 410.080,29	- 4,69
PQ	8.811.631,96	9.103.159,14	9.130.248,23	- 27.089,09	- 0,30
RSTU	2.317.971,19	3.872.930,27	2.872.671,73	1.000.258,54	34,82
Total	**179.943.806,13**	**228.741.204,13**	**251.089.856,35**	**- 22.348.652,22**	**- 8,90**

Source: processed data

The magnitude of the deviation that occurs in the output forecast using the Leontief inverse matrix for the two years of observation is still within a relatively small range. However, the difference in tendencies between the two (over/under-estimated) deserves further study. Leontief's inverse matrix contains elements that can show the multiplier effect due to the linkage between sectors. The impact of the interaction between sectors can be visualized as a graphical economic landscape, which is the result of a multiplier product matrix.

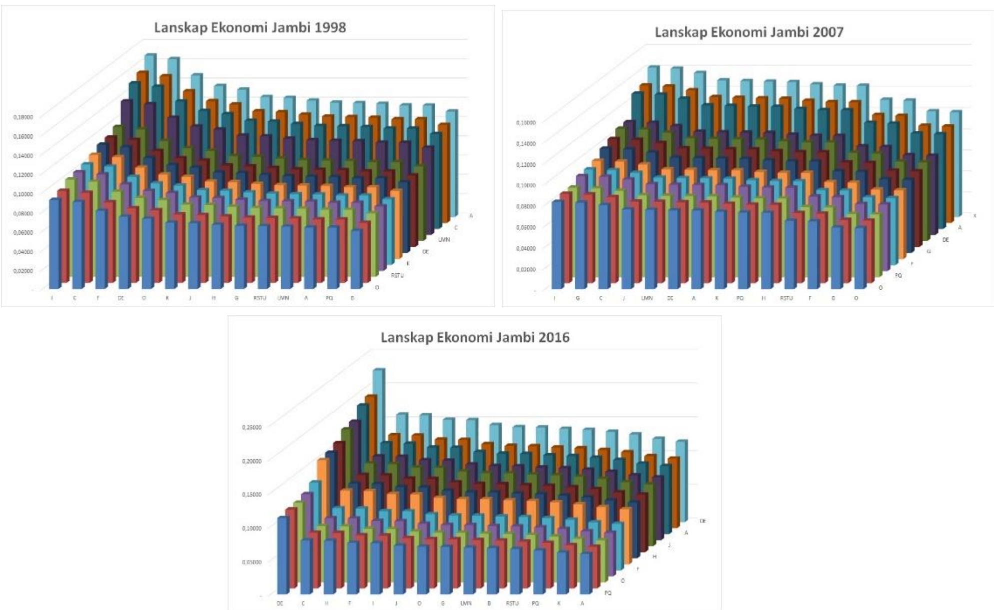

Figure 1. Jambi Economic Landscape

Changes in the value of the MPM (multiplier product matrix) arranged (sorted) based on the order in a particular year can describe a process of transformation of the economic structure that has taken place.

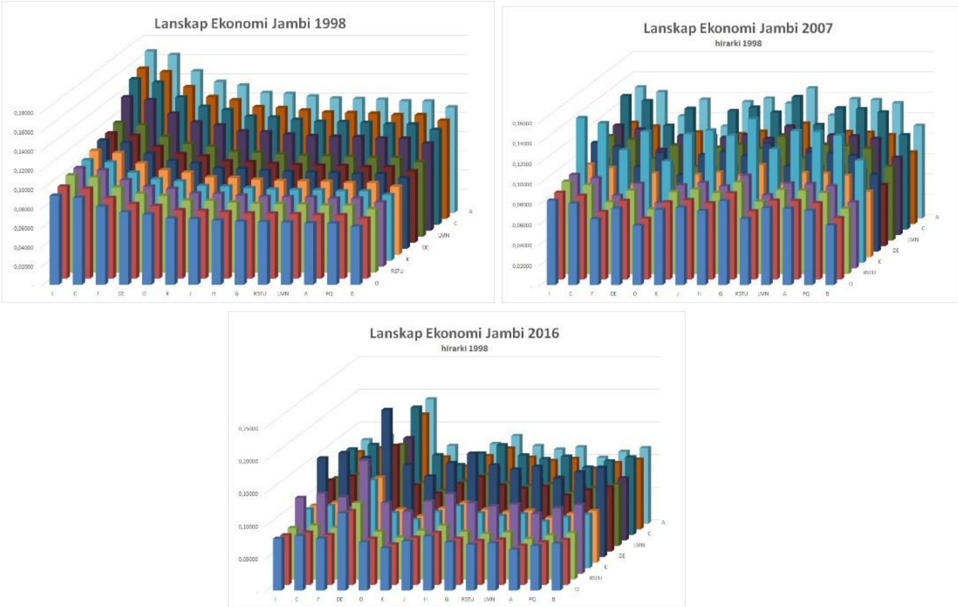

Figure 2. Jambi Economic Structure Transformation 1998-2007-2016

4. CONCLUSION

The Jambi Province IO table is quite accurate for forecasting with a deviation range of 8 percent. The transformation of Jambi Province's economic structure can be seen from the graphic visualization results of the 2007 and 2016 MPM which were arranged according to the 1998 inter-sector linkage interaction hierarchy.

The period of compiling regional IO tables over a period of nearly 10 years makes it possible to inaccurate forecasting results in their use. At least it is necessary to prepare the IO Table in a shorter period, a maximum of every 5 years. A more diverse sector classification that prioritizes local specificity is also suggested as the basis for preparing the next regional IO table. This research only uses a small number of mathematical equations that can be derived from the IO model, there are still many other mathematical models that can be utilized for future studies.

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