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Forecasting of direct material costs in the national economy using the RAS method based on data extrapolation

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Abstract: Stabilization and growth of the real sector of the economy require increased attention to the system of forecasting the development prospects of the country's economic sectors. In recent years, there has been an increase in interest in forecasting projects and methods related to forecasting industry, inter-industry, and interregional relations. In this direction, the solution to the problem of forecasting direct material costs of economic sectors is relevant. To solve this problem, the article conducts a study on the application of the RAS method. RAS is a widely used methodology for evaluating, balancing, or updating matrices. This method is the process of obtaining a final matrix from an initial general matrix, given specified sums for the rows and columns. The article analyzes the inter-industry balance of the economy of Azerbaijan, aggregated in the 14x14 dimension, for 2006-2016. At the next stage, based on the results of this period, a forecast matrix of intermediate products of this size for 2021 was calculated using the RAS method. The compiled balance sheet indicators were compared with the actual indicators for 2021. The obtained results confirmed the expediency of using the proposed method in drawing up comprehensive plans and forecasts for the country.
Keywords: *Calibration, Data extrapolation, Forecast matrix, Input-output tables, RAS method.*

1. Introduction

1.1.Literature Review

Early analysis of Leontief's input-output tables using the RAS method was reflected in the study of Stone and Bacharach [1]. The main objective of his research is to modify input-output tables so that they match the totals of the rows and columns. In such an iterative algorithm, the sum of the rows of a given table is increased so that it equals the sum of the search rows. In the next stage, the sum of the columns is ensured to be the same as the sum of the columns being searched.

For this reason, several iterative processes are performed to obtain a suitable result [2].

In the 1970s and 1980s, mainly theoretical problems of the RAS method were analyzed. The various conjectures put forward during this period were developed on the basis of compatibility proofs, examples of which are the entropy approaches of Bacharach [3] who used calculus and linear algebra, and Fienberg [4] who used entropy approaches. The issue of algorithm complexity and its efficient implementation was considered by Kalantari, et al. [5].

In recent years, the relevance of the issue of applying the RAS method to Leontief's input-output tables using uncertainty theory has increased. Initial evaluations of the application of the RAS method to Leontief's input-output tables using uncertainty theory were shown in the modified RAS method (MRAS) proposed by Allen and Lecomber [6].

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In their research, Gilchrist and St Louis [7] analyzed the issue of extending the RAS method to multiple dimensions. They performed a three-stage extension of the traditional RAS algorithm, called three-stage RAS (TRAS). As a result, such an extension allows adding constraints to arbitrary subsets of matrix elements [7].

Miller and Temurshoev [8] proposed a generalized RAS (GRAS) algorithm that improved this method and allowed the use of matrices with some negative elements. Later researchers proposed a variant of GRAS based on minimal information loss [8].

Pavia, et al. [9] compared the RAS method with existing alternative methods, treating it as an optimization problem. The results of this comparison showed that in some cases the RAS method outperformed other methods. The main advantage of the RAS method over optimization methods is its computational simplicity [9].

In general, existing research methods for estimating country input-output tables can be classified as the area ratio method, the commodity balance method, and the RAS method. Flegg and Tohmo [10] proposed several variants of the area ratio method and made comparisons [10]. The problem of multidimensional extension of the RAS method has also been developed and presented by scholars such as Lenzen, et al. [11].

1.2. Purpose of the Study

An analysis of the literature showed that, despite the relevance of the application of the RAS method for assessing input-output schedules on a national scale and the extensive research conducted in this area, it cannot be said that the problem has been completely solved. For this, the RAS method is developed in the article based on data extrapolation and applied to the country's economy. The obtained results are compared with actual indicators and their adequacy is confirmed.

2. Methods

2.1. Preliminary Notes

In economics, the relationship between different sectors of the national economy is described using input-output analysis. The main aspect of our analysis is to create an input-output table that more adequately describes the relationships between sectors for the forecast period.

At the same time, it should be noted that conducting empirical calculations in cases where only some parts of the input-output table are known is an unsolved problem [12]. As mentioned above, the RAS method is used only when the sums of the rows and columns of the table are known. The table calculated by the RAS method is estimated from the completely known original table in such a way that the resulting table matches the sum of the rows and columns of the original table. To begin with, let us analyze the application of the RAS method in the analysis of Leontief's input-output model of the country.

2.2. Instruments

In general, the calculation of the coefficients of direct material costs according to the RAS method can be expressed as follows:

$$A[i,j,(t+1)]= =R[i,j,(t+1)]*A[i,j,t]*S[i,j,(t+1)] \quad (1)$$

Here,

- $A[i, j, (t + 1)]$ - matrix of coefficients of direct material costs (endogenous variable) for the year (t + 1) in final consumer prices (size 14*14 in our calculations);
- $A[i,j,t]$-matrix of coefficients of direct material costs of year t in final consumer prices (endogenous variable) (size 14*14);
- $R[i,j,(t+1)]$-diagonal matrix (size 14 * 14) (endogenous variable);
- $S[i,j,(t+1)]$- diagonal matrix (size 14 * 14) (endogenous variable);
- Exogenous variables (independent, measurement variables):

- X[i,(t+1)]-column vector of gross output of the (i)-th sector in current prices;
- U[j,(t+1)] - column vector of the total product of (j) deposits at current prices;

M[j,(t+1)] = U(j,(t+1))/X(j,(t+1)) - specific weight of the column-vector of intermediate costs.

In the model under consideration, the following measurement option was selected for calculating RAS:

1). S[1,i,(t+1)]=(0,999 + 0,002*rand);
2). R[1,i,(t+1)]=(0.999 + 0.002*rand);
3). S[3,i,(t+1)]={S[Opt.,1,i,(t+1)]+ +S[Opt.,2,i,(t+1)]}/2;
4). R[3,i,(t+1)]={R[Opt.,1,i,(t+1)]+ +R[Opt.,2,i,(t+1)]}/2.

The multivariate method is also used to compile forecasts of the Leontief input-output table using the RAS methodology for the national economy. In the multivariate expansion method, area, period, and import/export decompositions can be used as dimensions. In this case, the multivariate RAS method will be applied to estimate the marginal sums of all input-output tables for the period (2006-2016).

2.3. The Author's Approach to the Problem

Using the traditional RAS method, we can estimate the Leontief input-output table for the country's economy. However, calculations have shown that the level of consistency of tables compiled in this way is low and some elements of the results obtained may be lower or higher than the real value of the national table. The reason for this was that the base period for the forecast was the previous year.

To solve this problem, we use the extrapolation method, using data for at least the last 15 years for forecasting. It is necessary to determine the total calculated values of the rows and columns of the table "Distribution of intermediate products" forecasted for 2021. Then, using the traditional RAS method, it is necessary to calculate the forecast distribution matrix of intermediate products.

Extrapolation is a method of scientific research based on the transfer of past and present trends, patterns and relationships to the future development of the forecast object. Extrapolation methods include the "moving average method", "exponential smoothing method", and "least mean squares method".

The essence of the least squares method is to minimize the sum of the squares of the deviations between the observed and calculated values. The smaller the distance between the actual indicators and the calculated indicators, the more accurate the forecasts based on the regression equation [13].

The theoretical essence of the phenomenon under study is that it represents a change in the trend over time, which plays a key role in choosing the dependence curve. Here it is necessary to take into account the nature of the growth of time trends. If the growth of the intermediate product follows an arithmetic progression, then smoothing is carried out along a straight line. If the growth is a geometric progression, then smoothing should be done using an exponential function. Smoothing time trends using the least squares method allows us to reflect the pattern of development of the phenomenon under study. At this stage, when trying to describe an economic event using a mathematical equation, the forecast will be accurate for a short period of time, and the regression equation must be recalculated as new data arrives.

The process of forecasting direct cost coefficients at the country level using the multivariate RAS method consists of determining the trends of coefficients for reporting years using mathematical statistics methods and then extrapolating these trends to the future period [14]. A development of this approach is the construction of regression equations for cost coefficients, where the change in each coefficient is set depending on a certain number of factors.

2.4. Problem Solving Factors

When constructing regression equations, various technical and economic indicators and price factors that influence a particular coefficient (changes in prices for consumed material resources and manufactured products, etc.) can be taken into account. For this reason, econometric constructions

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should be applied after making certain adjustments to the original series of direct cost coefficients. The essence of this adjustment is as follows. For each cost coefficient aij(t), a regression model of the following type is constructed:

$a_{ij}(t) = f(t)+w_1+w_2+\dots w_n+\varepsilon_t$, (2)

where f(t) is the time-varying function; $w_1+ w_2+\dots w_n$ are the changes as a result of the impact; ε_t - indicates deviations caused by statistical error.

In practical calculations, f(t) is most often used as a parabolic or linear function. After calculating the parameters f(t) using the RAS method and calculating the indicators taking into account the effects, the adjusted direct cost coefficients for 2021 (in our example) were determined as follows:

$a_{2021ij}(t) = f(t) +\varepsilon_t$ (3)

When using adjusted values of direct cost coefficients compiled on the basis of the indicators of the reporting period of the inter-industry balance (2006, 2011, 2016), the identity of the balance tables for 2016 may not be observed. This requires adjusting the prices of the industry components of the total product or final product to eliminate the resulting imbalances.

In this case, the final product must be adjusted. First of all, the calculated values of the functional elements of working capital and the import-export balance in 2016 may be inaccurate due to an increase in working capital or the import-export balance of the product [15]. It should be noted that the volume of industry production in the inter-industry balance is formed on the basis of data collected periodically by state statistics agencies.

3. Methods

3.1. The Distribution of İntermediate Products Across The 14 Sectors

Our objective is to forecast direct cost coefficients (a_{ij}) for the Republic of Azerbaijan for 2021 using the RAS method based on data extrapolation. At the same time, we work on the multidimensional RAS method in research, expand the theory and present its application.

To forecast the input-output tables for the Republic of Azerbaijan using the RAS method, the "Inter-industry Balance Indicators" compiled by the State Statistical Committee for 2006, 2011, 2016 and 2021 were used. Since the measurement at the level of "Inter-industry Balance indicators" is too large for our purposes, Leontief's input-output tables were aggregated into 14 economic categories defined by the Delphi method.

Accordingly, Table 1 presents the distribution of intermediate products across the 14 sectors that are the objects of study in 2021.

Table 1.
Intermediate products for the Republic of Azerbaijan for 2021.

Economic sectors	1	2	3	…	…	13	14	Total
1. Agriculture, fishing and forest products	1387955	0	612745	…	…	165	0	2049769
2. Products of the mining industry	0	586743	1307535	…	…	39	8303	2993378
3. Manufacturing industry	813452	293374	1990864	…	…	627371	112165	9819512
4. Electricity, gas and water	259682	46079	343790	…	…	49360	25643	1456854
5. Construction	165456	46127	1044940	…	…	83639	85030	3756961
6. Trade services	915787	449961	1522195	…	…	36778	39436	4973590
7. Services of hotels and restaurants	6673	3285	15322	…	…	4437	68021	272701
8. Transport, postal and communication	650545	1963443	1797498	…	…	52979	76176	8256755
9. Financial, insurance and pension services	43216	37601	249615	…	…	15848	48091	1911752
10. Real Estate, Lease and Other Commercial Services	160329	37897	228133	…	…	65090	174874	4949772
11.Services in public administ. defense, social insurance	0	3801	1069	…	…	2279	907	153542
12. Educational Services	26058	38029	150413	…	…	18883	12115	1473254
13. Health and social services	4906	771	2167	…	…	15271	16815	165676
14. Utility and other services	762	22961	8186	…	…	52337	108766	568593
Total	4434821	3530071	9274471	…	…	1024475	776342	

3.2. Data Extrapolation

The distribution of projected intermediate products by 14 sectors for 2021 by columns was calculated using the extrapolation method, which is shown in Table 2. The table shows the shares of intermediate products of each sector of the economy in the total volume of intermediate products (in %) and a comparison of projected prices determined for 2021 using the extrapolation method with actual prices. In our example, n_1, n_2, n_3 show the final indicators of intermediate products by columns (for 14 industries) for 2006, 2011 and 2016, respectively.

Table 2.
Distribution of intermediate products forecast for 2021 by columns using the extrapolation method.

Sectors	n1	%	n2	%	n3	%	Predicted Column (2021)	Actual -2021	Deviation from the actual indicator (%)
1	781000	7.3	2286745	11.4	2707897	9.0	3852111	4434821	15
2	1039800	9.8	1804461	9.0	2636206	8.8	3423228	3530071	3
3	3291800	30.9	4152358	20.7	5428554	18.1	7627658	9274471	22
4	515900	4.8	758915.5	3.8	1293090	4.3	1633159	1742137	7
5	2178000	20.5	4694365	23.4	6882656	23.0	8889663	7057086	-21
6	601200	5.6	1590735	7.9	3049844	10.2	4195904	4665541	11
7	54300	0.5	297394.6	1.5	692553.9	2.3	186336.7	212351.2	14
8	1032300	9.7	900533.8	4.5	1818081	6.1	2036086	3950526	94
9	98000	0.9	227042.7	1.1	323721.3	1.1	441975.9	595205.6	35
10	248300	2.3	786772.4	3.9	790461	2.6	1450672	1944093	34
11	340200	3.2	1166540	5.8	2141216	7.1	3017001	2800303	-7
12	126800	1.2	237817.4	1.2	512993	1.7	678729.8	794685.7	17
13	128300	1.2	425737.8	2.1	593381.1	2.0	947554.1	1024475	8
14	205100	1.9	758669.6	3.8	1091630	3.6	784996.5	776342.2	-1
Total	10641000	100	20088087	100	29962285	100	39165075	42802109	9

As can be seen from the table, the final agreement between the forecast and actual figures was high (91%). However, it should be noted that in column 8 (Transport, postal and communication and Real Estate, Lease and Other Commercial Services) there was a large difference (94%). This is due to the large investments of the state in these sectors during the period under review.

The distribution of intermediate products by type for 2021 is determined in a similar way. A comparison of forecast indicators by rows with actual values is given in Table 3.

Table 3.
Distribution of intermediate products projected by rows for 2021 using the extrapolation method

Sectors	**n1**	**%**	**n2**	**%**	**n3**	**%**	**Predicted rows (2021**	**Actual (2021)**	**Deviation from the actual indicator (%)**
1	1011423	9.5	1543761	7.7	1241057	4.1	1515047	2049769	35
2	1518704	14.2	2120547	10.5	3884069	13.0	4873138	2993378	-39
3	3328011	31.2	5568943	27.6	8869261	29.6	11463322	9819512	-14
4	369542	3.5	747265	3.7	1199566	4.0	1602148	1456854	-9
5	904504	8.5	2536456	12.6	2898061	9.7	4106564	3756961	-9
6	638997	6.0	954152.5	4.7	2903697	9.7	3963648	4973590	25
7	123930	1.2	194109.8	1.0	301352.2	1.0	383886.2	272701.4	-29
8	1850636	17.3	1673780	8.3	1713879	5.7	4261665	8256755	94
9	119148	1.1	873764.3	4.3	1485260	5.0	1992169	1911752	-4
10	422975	4.0	1189131	5.9	1907938	6.4	2658310	4949772	86
11	35623	0.3	1247449	6.2	1429834	4.8	155179.3	153541.8	-1
12	13901	0.1	1055718	5.2	794560.5	2.7	1402053	1473254	5
13	197812	1.9	40366.38	0.2	71508.01	0.2	175612	165675.6	-6
14	146792	1.4	425686.4	2.1	1262243	4.2	612333.2	568593	-7
Total	10681998	100	20171130	100	29962285	100	39165075	42802109	9

3.3. Construction of a forecast input-output table for the Republic of Azerbaijan using the RAS method based on data extrapolation.

The rows and columns of Table 4 were determined respectively using Table 2 and Table 3, which were constructed using the extrapolation method. In the next step, the distribution of the predicted intermediate products was calculated using the traditional RAS method. During the calculation, we stop the iteration process because the matrix A27 (determined after the 27th iteration) takes into account the sum in both the column and the row. If we did not get a suitable result, we would continue the iteration, multiplying each element by the ratio of the final column value to the actual final column value. The distribution of the forecast of intermediate products for the economy of Azerbaijan for 2021 by rows and columns is presented in Table 4 that we have compiled.

Table 4.
Distribution of forecast intermediate products for 2021 by rows and columns using the RAS method

	1	2	3	4	…	…	12	13	14	Total
1	983101	-	516409	-	…	…	425	243	7254	1515047
2	7	1808992	884575	961203	…	…	-	-	928	4873138
3	832304	641491	2623870	185506	…	…	108537	402389	182976	11463322
4	505954	59332	413799	73859	…	…	36070	43063	14627	1602148
5	195314	54281	173310	103676	…	…	170276	166121	106754	4106564
6	843446	101428	1277855	28891	…	…	33998	82722	29305	3963648
7	13925	11048	14699	4166	…	…	48192	17912	77391	383886
8	334007	486198	880050	226451	…	…	26093	22334	24450	4261665
9	105785	46822	230554	17130	…	…	28370	24633	26018	1992169
10	12121	89669	167572	22634	…	…	60468	84609	141002	2658310
11	292	10620	4631	2121	…	…	3684	1954	8515	155179
12	10078	86086	428539	750	…	…	87965	25032	56092	1402053
13	14931	2427	2876	192	…	…	31538	63439	20489	175612
14	849	24853	8928	6589	…	…	43111	13101	89193	612333
Total	3852115	3423248	7627667	1633170	…	…	678727	947551	784993	

4. Results and Discussion

It should be noted that the method used and the results obtained depend on the available initial data and the theory of the forecasting process and are mainly used when the actual database is presented in matrix form. The marginal sum of the rows and columns of the forecasting matrix constructed in this way is also reflected in the model.

Figure 1 shows a graphical representation of the solution to the problem for the "Agriculture, fishing and forest products" sector.

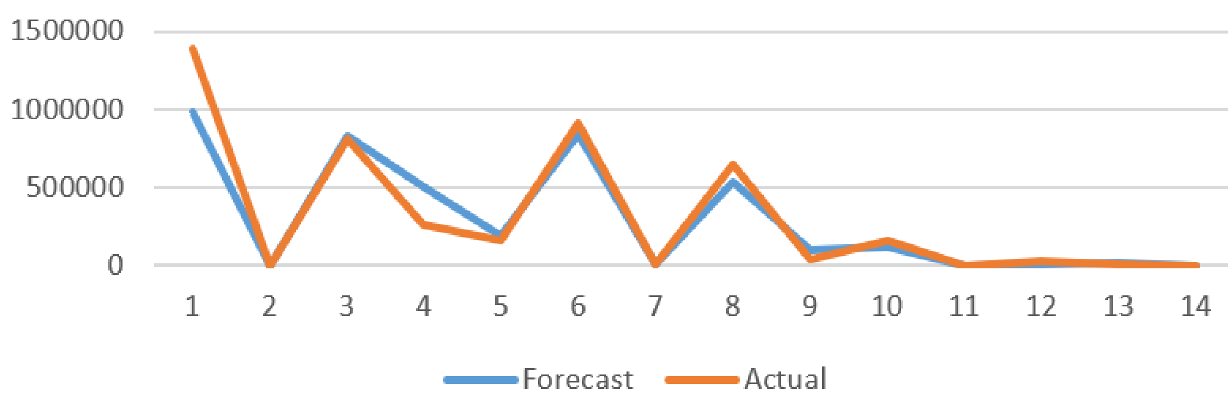

Figure 1.
Comparison of the forecasted indicators of intermediate products for the sector " Agriculture, fishing and forest products " for 2021 using the RAS method with the actual indicators.

It should be noted that graphical analysis of other industries also confirmed this compatibility.Our goal is to determine the predicted direct cost ratios for 2021 and compare these determined ratios with the estimated (actual) figures for 2021

Using the indicators of intermediate products of economic sectors calculated using the RAS method and the estimated indicators of total output for 2021, the forecast values of direct cost coefficients for a number of sectors were determined, which are presented in Table 5.

Table 5.
Forecasted and actual values of direct cost coefficients (a_{ij}) for Azerbaijan for 2021.

Sectors	Agriculture. fishing and forest products		Products of the mining industry		Manufacturing industry	
	Forecast	Fact	Forecast	Fact	Forecast	Fact
1	0.108799	0.12537	0	0	0.016344	0.01939
2	6.09E-07	0	0.049043	0.03591	0.037997	0.04138
3	0.075178	0.07348	0.017391	0.00795	0.083046	0.07301
4	0.0457	0.02346	0.001609	0.00125	0.013097	0.01088
5	0.017642	0.01494	0.001472	0.00125	0.008485	0.01307
6	0.076184	0.08272	0.00275	0.00182	0.040444	0.04818
7	0.001258	0.0006	0.0003	0.00009	0.000465	0.00048
8	0.040169	0.05876	0.043181	0.05323	0.047854	0.05689
9	0.009555	0.0089	0.001269	0.00102	0.007297	0.0079
10	0.001095	0.01448	0.002431	0.00183	0.006304	0.00722
11	2.64E-05	0	0.000188	0.0001	0.000147	0.00003
12	0.00191	0.00235	0.002334	0.00183	0.013563	0.00876
13	0.001349	0.00094	6.58E-05	0.00002	9.1E-05	0.00007
14	7.67E-05	0.00007	0.000674	0.00062	0.000283	0.00026

As can be seen from the table, the projected values of the direct cost coefficients (a_{ij}) set for 2021 correspond, on average, to the actual values calculated based on the SAM for that year by more than 90%. This indicator makes the proposed rule suitable for practical use.

5. Conclusion

In the practical calculations in the study, the calibration of the Leontief model was carried out at the upper level. The Leontief model combines intermediate inputs and added value at the upper level. The paper mainly proposes a new approach to the forecasting algorithm for intermediate inputs. The presented algorithm allows more adequate forecasting of the impact of changes in some sectors of the economy on others. The same model can be used to solve traffic forecasting problems. The applied solution algorithm is called the RAS algorithm, based on data extrapolation.

Using such a RAS model, the following problems can be solved:

1) Analysis of the inter-industry balance of the country's economy for previous years and preparation of forecast balances of intermediate products based on the results of this period.

2) Correct accounting of raw materials, materials, semi-finished products, ores, coal, fuel, parts, products, business services in production, transport, sales and production links along all technical and technological chains.

3) Compilation of prospective balance sheets taking into account possible changes in final consumer prices for the industries that make up the country's economy.

Using the forecast indicators of intermediate products, it is possible to forecast the indicators of direct costs, which increases the practical significance of the study. The econometric model of the method of adjusting the approximation for the forecast period of the coefficients of direct costs of the inter-industry balance allows the transfer of the t-th year (t+1) of the inter-industry balance to the next year. The initial data used in the study is the marginal part of the future matrix, which is the calculated matrix of the actual situation. The article also adds an algorithm for determining the forecasted direct cost coefficients (aij) in addition to the solution method by exponentially assigning the matrix of rows and columns of the forecasted "intermediate product allocation" table for 2021.

The algorithm presented here can also be used in many decision making models.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

References
[1] R. Stone and M. Bacharach, " The reconstruction of input-output tables: The RAS method," *Economic Journal*, vol. 80, no. 318, pp. 551-558, 1970. https://doi.org/10.2307/2229720
[2] R. Stone, J. Bates, and M. Bacharach, "Input-output relationships, 1954-1966. (A Programme for Growth)," vol. 3. London: Chapman & Hall, 1963.
[3] M. Bacharach, *Biproportional matrices and input-output change*. Cambridge, MA: Cambridge University Press, 1970.
[4] S. E. Fienberg, "An iterative procedure for estimation in contingency tables," *The Annals of Mathematical Statistics*, vol. 41, no. 3, pp. 907-917, 1970. https://doi.org/10.1214/aoms/1177696968
[5] B. Kalantari, I. Lari, F. Ricca, and B. Simeone, "On the complexity of general matrix scaling and entropy minimization via the RAS algorithm," *Mathematical Programming*, vol. 112, no. 2, pp. 371-401, 2008.
[6] R. I. G. Allen and J. R. C. Lecomber, *Some tests on a generalized version of RAS. In R. I. G. Allen & W. F. Gossling (Eds.), Estimating and Projecting Input-Output Coefficients*. London: Input-Output Publishing Company, 1975.
[7] D. A. Gilchrist and L. V. St Louis, "Completing input–output tables using partial information, with an application to Canadian data," *Economic Systems Research*, vol. 11, no. 2, pp. 185-194, 1999.
[8] R. E. Miller and U. Temurshoev, "Output upstreamness and input downstreamness of industries/countries in world production," GGDC Research Memorandum GD-133. Groningen Growth and Development Centre, University of Groningen, 2013, 2013.
[9] J. M. Pavia, B. Cabrer, and R. Sala, "Updating input–output matrices: Assessing alternatives through simulation," *Journal of Statistical Computation and Simulation*, vol. 79, no. 12, pp. 1467-1482, 2009.
[10] A. T. Flegg and T. Tohmo, "Estimating regional input coefficients and multipliers: The use of FLQ is not a gamble," *Regional Studies*, vol. 50, no. 2, pp. 310-325, 2016. https://doi.org/10.1080/00343404.2014.901499
[11] M. Lenzen, R. Wood, and T. Wiedmann, "Uncertainty analysis for multi-region input–output models–a case study of the UK's carbon footprint," *Economic Systems Research*, vol. 22, no. 1, pp. 43-63, 2010.
[12] A. S. Velichko, "Forecasting direct cost coefficients in conditions of incomplete statistical data," *Bulletin of TSUE*, vol. 1, pp. 78–87, 2011. http://elibrary.ru/item.asp?id=15640219
[13] A. Ajiono and T. Hariguna, "Comparison of three time series forecasting methods on linear regression, exponential smoothing and weighted moving average," *International Journal of Informatics and Information Systems*, vol. 6, no. 2, pp. 89-102, 2023. https://doi.org/10.47738/ijiis.v6i2.165
[14] A. F. T. Avelino, "Disaggregating input–output tables in time: The temporal input–output framework," *Economic Systems Research*, vol. 29, no. 3, pp. 313-334, 2017. https://doi.org/10.1080/09535314.2017.1290587
[15] H. Zheng, Q. Fang, C. Wang, Y. Jiang, and R. Ren, "Updating China's input-output tables series using MTT method and its comparison," *Economic Modelling*, vol. 74, pp. 186-193, 2018.

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