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Evaluating Relative Performances of Four Non-Survey Techniques of Updating Input-Output Coefficients

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1. Introduction

The underlying interdependence in an economy may be expressed by the input-output (I–O) relationship. The I–O analysis encompasses a wide range and numerous applications. It provides policy makers and economic analysts with a powerful tool for policy simulation and impact analysis. A host of national, regional, sectoral, and corporate analysis may be conducted via employment of I–O tables. These explorations, in turn, can result in deeper understanding of potential problems and their possible sources. Consequently, the analysts may either avoid the difficulties altogether, or be more adequately prepared to confront them by the virtue of being aware of their existence.

Construction of I–O tables demands an elaborate and accurate statistical apparatus along with well-trained personnel. Furthermore, even under the best conditions, a rather substantial time lag exists between the actual census date and construction and publication of the survey-based tables. In addition, constructing I–O tables through surveys is sometimes prohibitively costly. Due to lack of sufficient funding and inadequacy of pertinent apparatus and staff, the situation is exacerbated for regional tables and less developed countries.

The original I–O framework assumes constancy of coefficients over time. Intertemporal instability of I–O coefficients, however, is a well-established fact. It is the recognition of this instability, in conjunction with resource limitations, which compelled the I–O researchers to direct their attention to devise updating techniques to capture and incorporate the changes in the I–O tables. This pursuit has led to emergence of an impressive body of literature that came to be known as the 'shortcut,' 'partial-survey,' and 'non-survey' updating techniques. The proposed methods have been evaluated and analyzed from variety of perspectives and under various circumstances. To appreciate the dimensions of this field, suffice to mention few of the most notable survey papers.

Richardson (1972) presents a comprehensive examination and critique of non-survey methods. Allen and Gossling (1975) and Lecomber (1975) offer additional reviews of projects concerned with estimation and projection of I–O coefficients. Round (1983) evaluates 80 works and brings Richardson's survey up to date. Jensen and Hewings (1985) provide a critical review and evaluation of shortcut methods and the multipliers generated through these techniques. Polenske et al. (1986) furnish a review and critique of 25 research projects dealing with the RAS approach alone. Snower (1990) reviews some updating methods and their extension, and de Mello and Teixeira (1993) provide a more recent survey of updating techniques.

Non-survey updating methods are attempts to turn the fixed coefficient I–O model, i.e., a one-point observation of an economy, into a model that can incorporate the changes. It is hoped that updating will improve upon the results of using the most recent survey-based I–O table alone. Experiments, however, indicate mixed results. Some methods consistently yield superior forecasts, while others do not perform as well. Some techniques provide reasonable estimates at both holistic (operational) and partitive levels, while others yield acceptable results only at an operational level. The present work is an attempt to appraise the relative performances of four of these updating methods.

2. Updating Techniques

In I–O updating, non-survey techniques try to minimize the difference between the estimated and the original (survey based) tables. Thus, the problem is essentially reduced to defining 'closeness,' determining the appropriate constraints, and stating an 'objective function'. The 'closeness', however, may be measured in variety of ways. A linear measure, i.e., linear programming, a least-squares approach or LaGrangian technique, and 'information theory', are among suggestions. The pertinent 'objective function' may be stated in several ways. Suggested minimands include those by Stephen (1942), Friedlander (1961), Matuszewski et al. (1964), Schneider (1965), Theil (1967), Omar (1967), Almon (1968), Bacharach (1970), Lecomber (1975), Geary (1973), Lamel et al. (1974), Morrison and Thuman (1980), Mohr et al. (1987) and Ritzberger (1990).

The first method used in this paper is the biproportional adjustment or the RAS method. This approach was originally introduced by Deming and Stephen (1940) and Stephen (1942), and was applied to the I–O analysis by Stone and Brown (1962) and Stone et al. (1963). Formally the RAS method may be stated as:

$$A^t = [R][A^O][S]$$

subject to:

$$\sum_{j}^{n} r_i x_{ij}^0 s_j = u_i^t$$

$$\sum_{i}^{n} r_i x_{ij}^0 s_j = u_j^t$$

where $[R]$, $[S]$, v_j^t, u_i^t, x_{ij}^o, $[A^t]$, and $[A^0]$ are, respectively, diagonal matrices constructed from the vectors of row and column multipliers (r_i, substitution and s_j, fabrication effects), elements of the target year's marginal totals, elements of the intermediate input matrix of the base year, matrix of target year's coefficients, and the base year's matrix of coefficients.

The second technique utilized is the LaGrangian optimization method, (LAG), under Friedlander (1961) minimand. Denoting the sum total of relative discrepancy ratios of the elements of base and target matrices by (L), the problem may be stated as:

$$\text{Minimize } L = \sum_{i}^{n} \sum_{j}^{n} \frac{(x_{ij}^0 - x_{ij}^0)^2}{x_{ij}^0}$$

subject to:

$$\sum_{j}^{n} x_{ij}^t = u_i^t$$

$$\sum_{i}^{n} x_{ij}^t = v_j^t$$

where x_{ij}^t, x_{ij}^o, u_i^t and v_j^t, respectively, represent elements of the intermediate projected matrix, intermediate base year matrix, known column-wise, and known row-wise marginal totals of the projecting year matrix. The pertinent auxiliary function will be:

$$L = \sum_{i}^{n} \sum_{j}^{n} \frac{(x_{ij}^0 - (x_{ij}^0)^2}{x_{ij}^0} + \sum_{i}^{n} \lambda_i \left(u_i^t - \sum_{j}^{n} x_{ij}^t \right) + \sum_{j}^{n-l} \mu_j \left(v_j^t - \sum_{i}^{n} x_{ij}^t \right)$$

with λ_i and μ_j being the appropriate LaGrangian multipliers.

The third updating technique utilized in this work is known as 'transaction proportional to value added' (TPVA). This approach basically assumes that all transactions are proportional to the value added. That is, the amount of input used by industry (j) from the output of industry (i) is directly proportional to the value added by industry (j). The inference being that the usage of any input in production process of each commodity is a fixed proportion of the labor and capital used in that process. Formally:

$$\Psi_{ij} = \frac{x_{ij}^o}{v_j^o}$$

where x_{ij}^o and v_j^o are the amount of industry (i)'s output that is used by industry (j) as input, and the value added of the j-th sector. Designating the matrix of these proportions as ψ, the target year's interindustry demand can be obtained via:

$$X^t = [\Psi^o][V_j^o]$$

Adding the final demand vector to the intermediate demand yields the target year's gross output.

The fourth and final method utilized here is NAÏVE method, which assumes no change in the I–O coefficients between the base and target years. That is, in line with Leontief's original proposal (1936, 1941), it adopts the basic I–O assumption of intertemporal stability of coefficients. Thus, the base year's coefficients are simply applied to the target year's data. This approach is included for its simplicity and as a mean of testing the I–O coefficients' intertemporal stability. For if the coefficients were relatively constant, the NAÏVE method should yield reasonably good estimates.

3. Data

For experimental purposes, the former Soviet Union's Input-Output tables of 1966 and 1972, expressed in current producers' prices, are used. These tables serve as the base and the benchmark tables respectively. The aim is to identify, among four non-survey updating methods, the technique that yields the closest estimate to the actual 1972 table. To accomplish the task, projections of direct and inverse transaction matrices of 1972 table are obtained via use of the four selected updating techniques. In the next step, the resultant matrices are compared with the actual survey based 1972 coefficients. Consequently, the relative performances of the updating methods are determined.

As a matter of policy, the Soviet statistical authorities have never published an entire I–O table at one time. Segments of the I–O tables have appeared in various publications at different points and some portions have never been publicly available. This fact necessitates the collection of the fragmented data, from various I–O and non I–O related sources, and reconstruction of the tables. The tables used in the present study are reconstructed versions of the original Soviet tables. The reconstruction has been carried out by the staff at the Foreign Demographic Analysis Division of the Bureau of the Census of the U.S. Department of Commerce and reported in Treml et al. (1972, 1977), Kostinsky et al. (1976) and Gallik et al. (1983).

In some instances, to complete construction of an I–O table, some non-survey techniques are used. This practice will have some relevance in comparison of updating methods. For if a given technique is utilized in compilation of ‘actual’ tables, the comparison will be biased in favor of that particular technique. To the best of this author’s knowledge, none of the updating methods evaluated in this study was extensively employed in compilation of the Soviet tables. Therefore, the data are not materially biased in favor of any of the selected methods, and a fair evaluation may be conducted.

The original 1966 and 1972 Soviet tables are larger in size. Due to lack of reliable data, however, the tables had to be aggregated in the reconstruction process. For the purpose of the current project, to make the tables operationally compatible, further aggregation was necessary. The final versions used here contain 71 producing sectors, a column vector of final demand, and a row vector of value added. No use of employment and fixed capital data are being made.

In any I–O table some inaccuracies are present. The inaccuracies stem from statistical methods, data collection procedures, and processing practices. The Soviet tables are no exception, and as such do suffer from these deficiencies. The shortcomings, however, are no more acute in these tables than most other I–O tables. Thus, in this regard, when using the Soviet tables, no extraordinary step is necessary. These inaccuracies notwithstanding, conducting a credible analysis in the case of the Soviet Union requires cautious treatment of several other matters.

The first issue is the question of the reliability of the Soviet data. The second concern is the fact that the Soviet tables somewhat differ from their ‘Western’ counterparts in the definitions used and the manner in which the data are classified and presented. The third problem is the lack of information on certain portions of the Soviet tables, which gave rise to the need for estimating the missing segments in the reconstruction process, thereby introducing some additional errors in the final tables. Finally, for obvious political reasons, the published Soviet tables have been subject to some reclassifications and data manipulation by the Soviet authorities.

The aforementioned issues, while they merit consideration and warrant caution, do not impair the intended analysis of the present study. To have reliable results, two basic issues must be addressed. First, it should be determined whether the reconstructed tables are reasonable surrogates of the original tables. In other words, do the reconstructed tables reasonably approximate the original tables? The second issue is the reliability and consistency of the original data. That is, whether or not the original tables (and their reconstructed counterparts) accurately represent the underlying economic relationships among the various sectors in the Soviet Union, or at the very least that the data over the years have been presented in a consistent manner.

The reconstructed Soviet tables are compiled by using data from a variety of sources. As detailed, among other works by Treml et al. (1972, 1977), Kostinsky et al. (1976) and Gallik et al. (1983), the data for the most part have been thoroughly examined and cross-checked. This scrutiny and the fact that the tables, based on Gallik et al. (1983), are basically compatible with the Soviet national income and product, lend support to the proposition that the reconstructed tables are a close approximation of the original Soviet data as well as the assertion of data consistency.

With regards to the missing portions (thus estimated values), as noted by Gallik et al. (1983), the number of such estimates is not high in these tables. In the entire 88-sector 1972 table, for instance, 18% of the total entries are estimated. In the same year's 18-sector table only 14% of estimates are based on non-input – output data. Moreover, in the same year's 88-sector table, 85 of the 88 sectors in the reconstructed table appear in the original published table. Although there are gaps in data for every sector, sales and purchases of unpublished sectors account for less than 10% of the total interindustry flows (Gallik et al., 1983).

Overall, then, it can be concluded that the reconstructed tables are fairly close to the original tables and the fact that some portions of these tables are estimated, does not materially alter the tables. The last point is further strengthened in the present work due to presence of two additional factors. First, the current project uses the interindustry matrix. As noted above, the interindustry matrix contains few estimates and is mostly based on published actual data. Thus, the tables used here are almost identical to the actual interindustry matrices of the Soviet Union. Second, in this work, the tables had to be aggregated from 88 to 71 sectors. The aggregation further reduces the number of estimated cells, making the tables even closer to the original I–O data.

Upon concluding that the reconstructed Soviet I–O tables, particularly their interindustry matrices, fairly represent the original tables, some explanations regarding the issue of data reliability and consistency are in order. To reiterate, the goal of the present research is to compare the relative performances of four updating techniques. What is examined here is the efficiency of various techniques in updating I–O tables, and not evaluation, study, or assessment of the Soviet economy. No structural or economic inferences about the Soviet economy have been made. Neither are the results used (nor should be used) to offer or imply any policy recommendation.

Considering these points, the aims of this project may be accomplished. For, at worst, the Soviet tables have been deliberately tampered with and contaminated with false data. The distortion, however, is not pointless and indiscriminate. If present, the misrepresentation is designed to conceal some facts about the economy and prevent their disclosure. Whatever the reason may be, the Soviet statistical authorities must have performed their camouflage in a uniform and consistent manner. For if they were not consistent, given the existence of data from other sources such as trade partners, allies, international agencies, individual Soviet Republics, regional data, and other statistics from the Soviet Union itself, comparative studies would have surely exposed the inconsistencies. The exposure, then, would have defeated the purpose of the original falsification by compromising the information they were trying to protect. Thus, it is safe to infer that the Soviet authorities were at least consistent in their disguise. The consistency, then, will make the tables useable in the context of the present experiment. In other words, so long as the two matrices used here are consistent, even though they may contain false or distorted data, the comparison of updating techniques can be safely carried out. This assertion is valid since the goal is to identify the best method of updating I–O coefficients and not economic or policy analysis.

4. Matrix Comparison and Concept of Closeness

Assessment of efficiency and evaluating the performances of updating methods involves comparison of the target year's simulated and actual tables. The comparison of matrices, however, is not a straightforward task. The crux of the matter is to determine the closeness of the projected and actual survey-based matrices. Furthermore, a decision should be made as to whether the closeness of the estimated direct table is more important or the accuracy of its associated Leontief inverse matrix and the respective multipliers. In other words, in matrix comparison, should researchers be more concerned with cell-by-cell accuracy of the matrices, or should the goal be a general operational accuracy of the matrices as a whole?

Jensen (1980) terms these two concepts of accuracy, 'partitive' and 'holistic' respectively, and argues that while partitive accuracy is not achievable, a holistic accuracy test is a sufficient means of comparing matrices in an I–O analysis. The issue, however, is far from being settled. For, even after deciding on the desirability of the 'partitive' or 'holistic' accuracy, one must still choose a criterion for comparative evaluation of competing techniques.

A variety of accuracy measures have been proposed to address this need. Unfortunately, no one criterion is viewed to be universally acceptable or superior to others in assessing the closeness. Some criteria, however, are generally more plausible than others. The actual choice heavily depends on particulars of each case, since the appropriateness is not uniform and universal.

To somewhat resolve the issue, a 'package' of complementary accuracy tests is suggested in place of a single criterion (e.g., Butterfield and Mules, 1980). Since each criterion emphasizes a certain aspect of the comparison, a carefully assembled 'package' of statistical tests and accuracy measures will ensure, to the extent possible, that the shortcomings of one criterion are compensated for through inclusion of other tests. The 'package', however, need not be exhaustive and a subset of all available tests should suffice. This is because several of the criterias gauge the same aspect of the 'closeness'. Hence, inclusion of all available measures provides neither additional information nor remedy the deficiencies associated with the closeness tests.

The elements of the 'package' of accuracy tests used in the present work are selected from the set of available criterias and include: Number of Negative Coefficients; Mean Absolute Deviation; Mean, Standard Deviation, and Maximum Value of Coefficient of Equality; Theil's *U* (along with its components' UM, US, and UC); Degree of Approximation (at 5, 10, and 20%); Root Mean Square; Mean, Standard Deviation, and Maximum Value of the estimated coefficients; and Standardized Total Percentage Error. Detailed explanations of these statistics, along with discussion of their shortcomings and the logic of including them in the 'package' may be found, inter alia, in Smith and Morrison (1974), Harrigan et al. (1980), Butterfield and Mules (1980), Round (1983), Kim (1984), Israilevich (1986), and Jalili (1994).

In addition to the above closeness tests, it is possible to identify and express a 'loss function' and evaluate the techniques accordingly. For instance, one may calculate the shortage and excess in the final demand that is associated with using each of the tables generated by the updating methods. Comparison of the results with the actual data, then, may be used to rank the updating techniques in terms of the losses that the users would have sustained by employing them.

Although the 'loss function' approach is interesting and potentially fruitful, it is not pursued here. The omission principally is due to the nature of the Soviet tables: that is, the structure of the final demand, the components of export and import, and their prices. For, if the configuration and pricing of the final demand, exports, and imports are largely motivated by political and not economic considerations, the comparison will not really yield the 'loss' incurred and the results will be rather meaningless. To make the comparison meaningful, all these peculiarities must be addressed. Furthermore, most available evidence, as well as *a priori* expectation, suggest that the *ranking* will not differ from those obtained via other closeness test. Thus, to avoid unnecessary complications, pursuit of this alternative is deferred to future studies.

5. Results

Since negative I–O coefficients are meaningless, a higher number of negatively estimated coefficients by an updating method may be considered as an indication of that method's weakness. The estimates obtained in this experiment through NAÏVE, RAS, and TPVA do not contain negative coefficients in either direct or inverse instances. The LAG technique, on the other hand, while it generates no negative coefficient in the inverse case, yields two negative estimates in the direct case.

The LaGrangian approach in its pure form, cannot guarantee generation of non-negative coefficients in the updating process. This inability, however, may be corrected via several approaches. It is possible to impose non-negativity conditions on all negatively estimated coefficients and re-estimate the entire matrix. This procedure is practical, but, as noted by Morrison and Thumann (1980), it is not mathematically satisfactory. The problem also, as suggested by Harrigan and Buchanan (1984) based on an idea proposed by Omar (1967), can be resolved using

Table I. Summary of estimating performances

	Degree of approximation			Coefficient of equality		
	5%	10%	20%	Mean	SD	Max
Direct:						
Actual	5041	5041	5041	0.8972	0.3037	1
NAÏVE	783	1044	1579	2.3107	23.032	1073.40
RAS	820	1083	1643	2.0403	16.260	661.82
TPVA	788	1069	1567	2.0553	19.896	866.77
LAG	792	1055	1599	2.0183	16.066	683.47
Inverse:						
Actual	5041	5041	5041	1.0000	0.0000	1
NAÏVE	544	990	1873	1.0205	1.0325	48.276
RAS	740	1389	2512	1.0713	0.7983	32.374
TPVA	399	759	1443	0.8640	0.9131	44.835
LAG	730	1367	2463	1.0772	0.8220	35.253

quadratic programming. Additionally, when the number of negatively estimated coefficients is relatively small, the negative values may be discarded without seriously compromising accuracy. Since the number of negative coefficients generated by the LAG method in this study is only two, in the interest of simplicity and fair comparison with other techniques, negative coefficients are disregarded.

In the next step, several additional measures of closeness are utilized. These measures are ‘Coefficient of Equality’ along with its mean, standard deviation, and maximum value, as well as the ‘Degree of Approximation’. The Coefficient of Equality, denoted as (θ), is calculated as the ratio of each estimated coefficient and its true value. In an ideal situation, the mean, standard deviation, and the maximum value of the Coefficients of Equality calculated for estimated matrices will be identical to those of the actual table. Degree of Approximation, is obtained through ($1-\theta$). It is used to determine the number of coefficients estimated by each technique that fall within a given percentage intervals of their true values.

Table I summarizes the values of mean, standard deviation, and maximum value of the Coefficient of Equality for all estimated coefficients. To facilitate the comparison, the actual (survey-based) values are also included. In addition, the table contains the Degree of Approximation, providing total number of estimated coefficients that lie within 5, 10, and 20% of their true values. These statistics shed some lights on the performances of the updating methods. However, it should be noted that if both estimated and actual coefficients are zero, or when one is zero and the other is very small, these measures could be meaningless or misleading.

According to Table I, in direct cases, none of the techniques have mean, standard deviation, or maximum values that are close to the actual data. Vast variations, large

Table II. Absolute and relative measures of forecasting accuracy

	MAD	STPE	RMS	U	UM	US	UC
Direct:							
NAÏVE	0.00222	0.29379	0.07492	0.12456	0.00002	0.00005	0.99993
RAS	0.00199	0.26347	0.05899	0.09800	0.00000	0.00008	0.99992
TPVA	0.00235	0.31140	0.08623	0.15137	0.00009	0.00139	0.99852
LAG	0.00205	0.27168	0.06150	0.10202	0.00000	0.00011	0.99989
Inverse:							
NAÏVE	0.00435	0.14377	0.12210	0.04976	0.00015	0.00025	0.99960
RAS	0.00323	0.10664	0.08773	0.03547	0.00000	0.00000	1.00000
TPVA	0.00541	0.17887	0.16551	0.06809	0.00037	0.00071	0.99891
LAG	0.00330	0.10908	0.09120	0.03690	0.00000	0.00000	1.00000

means, and large maximum values indicate that none of the methods is capable of closely duplicating the actual data or limiting the variation in the individual estimated coefficients. In the inverse cases, the means of the coefficients of equality are substantially closer to the actual value. The relevant standard deviations are smaller but still high and suggest a sizeable variation in the estimates. The maximum values of the coefficients of equality, although less than their counterparts in the direct coefficient cases, are still large and further reaffirm the existence of a wide range of estimates. With the exception of TPVA, however, the means of estimated matrices are rather close to the actual mean.

It seems, then, none of the methods is able to closely reproduce the actual table in either direct or inverse cases. The apparent poor estimates, more than being an evidence of any technique's estimating power, are probably due to the existence of very small values in the actual data which in turn create large values for the standard deviation and maximum values of the coefficients of equality.

As indicated by the Degrees of Approximation, in neither direct nor inverse cases, does an impressive number of estimated coefficients fall within the desired percentage of their true values. Not surprisingly, however, as a wider error range is selected, updating methods become more robust.

To complement the previous tests, additional measures of distance are utilized to compare the estimated direct and inverse coefficients with the actual data. Table II provides the results. Since nonstandardized measures are affected by zero coefficients, standardized measures are also included among the test criteria. It should be noted that there is no objective basis to judge these values. These measures lack parametric properties, thus do not lend themselves to tests of significance. Hence, their values may not be used to judge any estimated matrix in absolute terms and only relative performances of the techniques may be deduced through comparison

Table III. Mean and standard deviation of predicted coefficients

	Mean	Standard deviation	Maximum value
Direct:			
Actual	0.00754	0.03465	0.70512
NAÏVE	0.00724	0.03519	0.90439
RAS	0.00754	0.03518	0.71255
TPVA	0.00672	0.03144	0.63717
LAG	0.00754	0.03529	0.71581
Inverse:			
Actual	0.03026	0.14357	2.05370
NAÏVE	0.02879	0.14163	1.84332
RAS	0.03026	0.14370	2.04409
TPVA	0.02706	0.13915	2.15907
LAG	0.03026	0.14349	2.05249

of the results. For the purpose of this comparison, with one exception, the closer the value of these statistics to zero the better the results. The exception is UC, where the unity is the optimal value.

The criterions included in table two consist of Mean Absolute Deviation, Standardized Total Percentage Error, Root Mean Square, Theil's *U* statistics, UM, US, and UC. The last three measures are components of the Theil's *U* and, respectively, represent measure of systematic error, variance, and covariance of the estimates. It must be emphasized that the values of the components of Theil's *U* in isolation do not indicate good or bad estimates. These values must only be evaluated in conjunction with the value of Theil's *U*, because the components merely decompose Theil's *U*, and within that context alone provide some insight into the variations due to bias of estimation and the variance and covariance of *U*.

As additional supplementary measures, Mean, Standard Deviation, and Maximum Values of the estimates are utilized to compare the updated and actual matrices. A good estimate should have a mean and a standard deviation close to those of the actual table. Comparison of the maximum values of estimated and actual coefficients should provide an approximate measure of performance of an estimation procedure. Table III tabulates these statistics for various updating techniques alongside their counterparts from the actual benchmark tables for direct and inverse coefficients.

In the case of direct coefficients, RAS and LAG estimates have means that are identical to that of the actual table, while NAÏVE poses a mean that is close to the actual mean. TPVA, however, fares much less favorably. Based on standard deviation, all methods except TPVA perform very close to the actual table. With regard to the maximum value of the estimated coefficients, RAS and LAG techniques generate good values, while NAÏVE and TPVA, do not produce good estimates. For inverse coefficients the situation is similar. LAG and RAS methods have means that exactly match the actual mean. NAÏVE and TPVA on the other hand, underestimate the mean of inverse coefficients. RAS and LAG generate standard deviations that are identical to that of the actual inverse matrix, while NAÏVE and TPVA do not. Regarding the maximum values, RAS and LAG estimates have the same maximum value as the actual matrix, while TPVA and NAÏVE deviate from this value. Therefore, according to the mean, standard deviation, and maximum value of the coefficients, it seems that some of the methods have the same or very close central tendency and dispersion as the actual data, which could be an indication of close fits.

6. Conclusion

Prior to rendering any judgement, several points must be clarified. First, in evaluation of the results, not all tests of closeness carry the same weight. This implies that an updating method may be judged inferior to another if it has been ranked higher based on several less important or less conclusive measures, while ranked lower by more important or conclusive tests. Second, the data used here pertained to a limited time span and geographical location. That is, the experiments are limited in nature and scope. Thus, the results may not be universally applicable, spatially or intertemporally, without further exploration. Third, the difference in the construction process of the original tables and the later reconstruction procedure by non-Soviet analysts can cause some incompatibility between the two tables, leading to some inaccuracies in the estimates. Finally, the question of reliability of the Soviet data must not be disregarded.

The Soviet tables used in this work have been reconstructed in the US and, to the extent possible, have been checked. This, however, does not indicate complete accuracy, warranting unconditional acceptance. For despite all rechecking, the data fundamentally originated from the Soviet Union itself. In fact, the somewhat unusual behavior of the estimates (large means, large standard errors, and many small or empty cells) could be indicative of concealment or even falsification of data by the Soviet authorities in order to hide their true nature and purposes. Hence, reproduction of the experiments with a different data set and comparison of the results with those obtained here might be a worthy project. With all these points in mind, some conclusions are nevertheless possible. The conclusions, though, must be viewed with caution and the results should be considered as interim results until they are supported or rejected by the outcome of other experiments.

In the evaluation process, as noted by Round (1983), comparisons of updated and actual tables do not present much information about the absolute efficiency of the respective updating techniques. Consequently, the closeness tests should only be used as a relative measure of the efficiency of various updating methods. It is the

Table IV. Summary ranking of estimation methods: direct coefficients

	NAÏVE	RAS	TPVA	LAG
Number of Negative Coefficients	1	1	1	4
Degree of Approximation (5%)	4	1	3	2
Degree of Approximation (10%)	4	1	2	3
Degree of Approximation (20%)	3	1	4	2
Mean of Coefficient of Equality	4	2	3	1
Standard Deviation of Coefficient of Equality	4	2	3	1
Maximum Value of Coefficient of Equality	4	1	3	2
Mean Absolute Deviation of estimated coefficients	3	1	4	2
Standardized Total Percentage Errors of estimates	3	1	4	2
Root Mean Square of estimates	3	1	4	2
Theil's *U* statistic	3	1	4	2
Mean of Theil's *U*	3	1	4	1
Standard Deviation of Theil's *U*	1	2	4	3
Covariance of Theil's *U*	1	2	4	3
Mean of estimated coefficients	3	1	4	1
Maximum Value of estimated coefficients	4	1	3	2
Standard Deviation of estimated coefficients	1	1	4	1

purpose of this study to *rank* the estimation techniques, and it is on this basis alone that a given technique is evaluated. Additionally, it should also be emphasized that no updating method is 'good' or 'bad' in absolute terms. Once a technique passed a certain set of criteria, determination of its 'goodness' depends on the circumstances governing any given experiment, i.e., the resources available, the specific objectives of the experiment, and the degree of error tolerance.

Generally, none of the estimation methods seem to be able to replicate the benchmark table in partitive sense. The Existence of large number of very small coefficients in the original table may be a major contributor to this outcome. An appreciable improvement is gained when one moves to a comparison of inverse coefficients, which indicates that better estimates are obtained in an operational (holistic) sense. This in turn implies that the updating techniques are more useful if holistic, rather than partitive, accuracy is desired. In relative terms, the RAS technique outperforms all other methods. The LAG method, despite some noticeable shortcomings, comes second in the ranking. The situation for NAÏVE and TPVA, however, is not clear-cut. Each method, depending on closeness tests, assumes the third or the fourth position. Overall, though, the NAÏVE method outranks the TPVA and occupies the third place, leaving the fourth place for TPVA.

Table V. Summary ranking of estimation methods: inverse coefficients

	NAÏVE	RAS	TPVA	LAG
Number of Negative Coefficients	1	1	1	1
Degree of Approximation (5%)	3	1	4	2
Degree of Approximation (10%)	3	1	4	2
Degree of Approximation (20%)	3	1	4	2
Mean of Coefficient of Equality	1	2	4	3
Standard Deviation of Coefficient of Equality	4	1	3	2
Maximum Value of Coefficient of Equality	4	1	3	2
Mean Absolute Deviation of estimated coefficients	3	1	4	2
Standardized Total Percentage Errors of estimates	3	1	4	2
Root Mean Square of estimates	3	1	4	2
Theil's *U* statistic	3	1	4	2
Mean of Theil's *U*	3	1	4	1
Standard Deviation of Theil's *U*	3	1	4	1
Covariance of Theil's *U*	3	1	4	1
Mean of estimated coefficients	3	1	4	1
Maximum Value of estimated coefficients	4	1	3	1
Standard Deviation of estimated coefficients	3	2	4	1

Tabular summaries of the ranking of the estimation methods', as gauged by the specified criteria for both direct and inverse coefficients, are presented in Tables IV and V. Ranking of the estimation methods by all closeness tests, strictly speaking, is not readily possible. Thus, in these cases, some arbitrary rule (such as narrowing the acceptance intervals) is used to allow presentation of all pertinent information needed for evaluation of the updating techniques. Numbers at the cross-section of a given method and a given criterion refer to the ranking of the former via utilization of the latter. When tied, the same number appears under all methods of equal ranks, and the next method in ranking is assigned its true position, i.e., 1, 1, 1, 4, indicates equal ranks for the first three methods and the rank of four for the last technique.

Despite the fact that NAÏVE method does not generate very accurate results, it is not drastically behind the top performing techniques. This is true particularly as error tolerance intervals are widened. The performance of the NAÏVE method could be an indication of the usefulness of utilizing the last survey-based table for the short term analysis, particularly when holistic accuracy is more important to the researchers and the resources do not allow employment of surveys or updating techniques. It is evident, however, that the I–O coefficients, even for a relatively stable economy and a short time span, do change over time. Thus, wholesale reliance on the most recent survey-based table for forecasting purposes may be misplaced. This assertion is fortified by the fact that RAS and LAG updating techniques generate estimates superior to that of the NAÏVE method. This may also be one piece of evidence in support of using updating procedures.

Overall, it may be concluded that, in the absence of survey-based tables, updating methods are immensely helpful to researchers, policy makers, and other users of I–O tables. These methods are particularly useful if holistic, rather than partitive, accuracy is sought. This is specially relevant since in most cases holistic accuracy and impact analysis are of primary concerns to the analysts. Ultimately, however, nothing replaces actual painstakingly constructed survey-based tables.

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