Increasing the Timeliness of U.S. Annual I-O Accounts

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Abstract

The timeliness of the U.S. input-output (I-O) accounts is a major concern for policymakers and industry analysts, as well as academics. In response, the Bureau of Economic Analysis initiated research in 2001 to identify, develop and implement an estimating method for producing more timely and reliable annual I-O accounts than are currently available. The research included reviewing the frameworks and methods currently used by other statistical agencies and academic researchers, obtaining more timely industry source data, and developing enhanced methods and processes for the automated updating and balancing of annual I-O tables. The results of this research indicate that our new automated updating and balancing method can reduce time lag for producing the annual I-O accounts from three years to one year without reducing quality. Our method is based on an adjusted RAS process that simultaneously balances the I-O table in producers' and purchasers' prices; uses more exogenous data; and processes tables at the most detailed level.

I. Introduction

The Bureau of Economic Analysis (BEA) reinstated its annual input-output (I-O) program in 1999 to provide more timely I-O tables and to provide information for the annual update of the national income and product accounts (NIPA's). BEA has produced annual tables for 1996, 1997 and 1998 and will release tables for 1999 later this year. The 1996 table was used to improve the 1999 benchmark revisions to the NIPA estimates for personal consumption expenditures (PCE). Each set of annual I-O tables has been produced with a time lag of three years – two years less than the lag associated with the benchmark tables that are produced every five years. BEA's goals are to prepare annual tables with a time lag of one year rather than the current three years and to produce the tables as a series that can be used to provide additional information for the annual revisions to the NIPA's. To meet these goals, BEA must develop techniques for balancing tables in a more automated manner while still producing valid results. This paper presents BEA's current research on improving automated techniques for balancing I-O tables. Specifically it shows that automated balancing of I-O use tables is substantially improved by:

- Balancing the I-O use table simultaneously in producers' as well as purchasers' prices;
- Providing exogenous values for value added and final expenditure components;
- Balancing the I-O use table at the most detailed level.

This paper is divided into five sections. The first section is this introduction. The second section describes the current methodology used to update and balance annual I-O tables. The third section provides a review of previous research related to our methodology. The fourth section describes tests of balancing techniques and provides empirical results of the tests. Finally, the fifth section provides summary remarks and identifies directions for future research.

II. Current Annual I-O Methodology

The U.S. annual I-O accounts provide estimates of the intermediate uses of commodities by industries, the commodity make up of final uses, and the value added of industries in the United States for a given year.[1] Unlike the I-O accounting systems of many other countries, the value added and final demand expenditures are not determined exogenously, but are part of the updating and balancing

1 . Note that the GDP by industry accounts are preferred over the I-O accounts in showing the distribution of value added across industries. For more information, please see Bob Parker (1997) "Note on Alternative Measures of Gross Product by Industry," Survey *of Current Business*,

process for the U.S. annual I-O accounts.

Currently the annual I-O estimates are prepared in five steps: (1) The output for each industry and commodity is estimated using annual source data; (2) the commodity composition of intermediate inputs for each industry is estimated; (3) the domestic supply of each commodity is estimated; (4) the initial commodity compositions of the GDP expenditure components for personal consumption expenditures (PCE), gross private fixed investment, and government consumption and investment expenditures are derived; and (5) the table is balanced.

Annual tables are estimated at approximately the same level of detail that is used to prepare the quinquennial benchmark I-O tables. In step one, source data are available to estimate output for most commodities and industries at the same level of detail as the benchmark I-O accounts. These source data, however, are based on sample surveys rather than on a complete economic census. The working level of detail (approximately 4,700 products, 760 industries, and 418 final use categories) is substantially greater than the publication level of detail (approximately 500 commodities and industries, and 13 final use categories). The working level is generally defined by the availability of source data and the amount of detail needed to identify the users of the commodities. The I-O tables, however, are balanced at a higher level of aggregation than this working level, because there is generally not sufficient information available to balance each product.

In step two, the estimates of the commodity compositions of intermediate inputs for industries are estimated from base-year relationships by adjusting for changes in real industry output and prices. Each industry's current-year output, valued in base-year dollars, is estimated using an industry price

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index that is calculated by weighting commodity price indexes with the commodity composition of each industry's output. Each industry's output, valued in base-year dollars, is then multiplied by that industry's direct requirements per dollar of output to obtain current-year inputs in base-year dollars. The results are then reflated to current-dollar values, using commodity price indexes, and then adding commodity taxes, transportation costs, and trade margins for commodities used by each industry.

In step three, domestic supply – the total value of goods and services available for consumption as intermediate inputs by industries or for personal consumption (PCE), gross private fixed investment, or government consumption or investment – is calculated as domestic commodity output, plus imports, less exports, and less the change in private inventories. Annual estimates for inventories, exports, and imports are based on the same source data and methods that are used for the quinquennial benchmark I-O accounts.

In step four, the initial estimates of the commodity composition of PCE and gross private fixed investment are based on the commodity-flow method.[2] The initial estimates for government expenditures are extrapolated using base-year relationships.

Finally, in step five, the initial distributions of domestic supply to all intermediate industries, PCE, gross private fixed investment, and government consumption and investment expenditures for commodities are adjusted so that their shares of domestic supply are similar to those in the base-year I-O accounts. These estimates are then further adjusted to reflect the current-year estimates of final

[2] Two alternative variants of the commodity flow method are used in the I-O accounts to estimate personal consumption and gross private fixed investment of commodities. In the first, the commodity flow value is the residual of domestic supply less intermediate consumption and government expenditures. In the second, the commodity flow value is a fixed proportion of domestic supply.

expenditures from the national income and product accounts (NIPA's). Differences between the supply and consumption of commodities are spread proportionally to intermediate inputs. Value added for each industry is estimated by subtracting the sum of its intermediate inputs from its output.

It is the fifth and last step that is most resource intensive and time consuming. The current method requires substantial resources to review and adjust estimates to constrained levels.

This step requires analysts to evaluate the fit between NIPA and annual I-O final use estimates. Typically, many repetitive attempts are required to either achieve agreement or to identify inconsistencies, possibly requiring revisions to the NIPA estimates, annual I-O estimates, or both.

Preliminary source data are generally available for preparing the annual I-O accounts with a lag of one year. However, because these data are typically revised over the following two years, a series of revisions to the annual I-O accounts would be required as well. Because of the high costs required to prepare and balance each set of annual I-O tables, we have delayed their preparation by three years, which is when final source data are generally available. To regularly prepare preliminary annual I-O accounts with a lag of one year, as well as revised and final annual I-O accounts with lags of two and three years, respectively, requires new procedures for updating and balancing that are less resource intensive while still producing reliable results.

III. Review of RAS and Other Updating and Balancing Adjustment Techniques

Various I-O balancing techniques have been developed over the years, of which the most commonly used is the RAS technique. There are several papers that survey and review different RAS or bi-proportional adjustment techniques. Two major works are by Lecomber (1975)[3] and more recently by Polenske (1997)[4]. Other related techniques have been developed over the years, from early work with linear-programming procedures (Matuszewski et al 1964)[5] and quadratic programming (Friedlander, 1961),[6] to Theil's (1967)[7] entropy approach and later the extensions by Bachaeach (1970)[8], Golan et al (1994)[9], McDougall (1999)[10], and Robinson et al (2001)[11].

The RAS or bi-proportional adjustment procedure has been "invented" several times in several

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3 Lecomber (1975). "A Critique Of Method of Adjusting, Updating, and Projecting Matrices", in *Estimating and Projecting Input-Output Coefficients*, (London: Input-Output Publishing Company, pp. 1-25).

4 Polenske K. (1997). "Current Uses of the RAS Techniques; a Critical Review", in *Prices, Growth and Cycles*. (London: MacMillan Press Ltd.)

5 Matuszewski, T.I., P.R. Pitts, and J. A. Sawyer (1964). "Linear-Programming Estimates of Changes in Input Coefficients", *Canadian Journal of Economics and Political Science*, Vol. 30, No. 2 (May), pp. 203-10.

6 Friedlander, D. (1961). "A Technique for Estimating the Elements of an Industry Matrix, Knowing the Row and Column Totals", *Journal of the Royal Statistical Society*, Series A, Vol. 123, part 3, pp. 412-20.

7 Theil, H. *Economics and Information Theory*. North-Holland, Amsterdam.

8 Bachaeach, M. "Biproportional Matrices and Input-Output Change", No. 16, University of Cambridge Department of Applied Economics Monographs. Cambridge University Press.

9 Golan, A., J. Judge, and S. Robinson (1994). "Recovering Information from Incomplete or Partial Multisectoral Economic Data, *Review of Economics and Statistics*, 76, pp. 541-49.

10 McDougall, R. (1999). "Entropy Theory and RAS Are Friends", (http://www.sjfi.dk/papers/McDougall.pdf).

11 Robinson, S., A. Cattaneo, and M. El-Said (2001). "Updating and Estimating a Social Accounting Matrix Using Cross Entropy Methods", *Economic Systems Research*, Vol. 13, No.1, pp. 47-64.

different disciplines. Bregman (1967)[12] indicated that "this method was proposed in the 1930s by the Leningrad architect G.V. Sheleikhovskii for calculating traffic flow." Deming and Stephan (1940)[13] applied this technique to the field of demographics. However, it was initially Leontief (1941)[14], and later Stone (1961)[15] and Stone and Brown (1962)[16], who extended the procedure to updating and balancing input-output tables.

Besides use matrices for I-O tables, the bi-proportional method has been applied in constructing other economic data such as for I-O make matrices and bilateral trade matrices. The RAS method continues to be used widely for adjusting national and regional input-output tables, Polenske (997).

The advantages and limitations of the RAS compared with other methods have been debated for years. However, some general conclusions include the following:

- With limited information, the standard RAS method generally produces results similar to other

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[12]Bregman, L.M.(1967). "Proof of the Convergence Of Sheleikhovskii's Method for a Problem with Transportation Constraints." *USSR Computational Mathematics and Mathematical Physics,* 1(1), pp. 191-204.

[13]Deming, W.E. and F.F. Stephen (1940). "On a Least Squares Adjustment of a Sampled Frequency Table When The Expected Marginal Totals Are Known," *Annuals of Mathematical Statistics,* Vol. 11: 427-44.

[14]Leontief, W. W. (1941). *The Structure of American Economy, 1919-1939.* (New York: Oxford University Press).

15 Stone, R. (1961). *Input-output and National Accounts.* Paris: Organization for European Economic Cooperation.

[16]Stone, R. and A. Brown (1962). *A Computable Model o f Economic Growth,* (A Programme for Growth, Vol 1), (London: Chapman and Hall).

methods, with no method being clearly superior. However, the linear and quadratic programming methods can yield negative elements, even though the initial data are non-negative unless additional constraints are explicitly introduced (Lecomber, 1975).

- While concerns about estimation errors resulting from the standard RAS procedure for updating I-O tables have been discussed by various researchers, and several tests have been conducted at both national and regional levels (for example, Almon (1968)[17] and Hinojosa (1978)[18]), results are not conclusive about which methods are more accurate, although large errors were found by some researchers (Lecomber (1969)[19], Hinojosa (1978), and Lynch (1986)[20]). For the RAS method, (Polenske, (1997) showed that errors can exceed thirty percent. However, other research also shows that RAS updates can be more reliable under favorable circumstances. Lecomber (1975) concluded that RAS updates are substantially improved by incorporating additional information to the standard RAS procedure. Specifically, he indicated that "it is often possible to determine *ex ante* (or from previous experience) which elements are likely to move differently from other elements in their row and column and thus merit special attention." Similarly, Polenske (1997) recommended that, given the possibility of

17 Almon, C. (1968). "Recent Methodological Advances in Input-Output in the United States and Canada", paper presented at the Fourth International Conference on Input-Output Techniques, Geneva.

18 Hinojosa, R. C. (1978). "A Performance Test of the Biproportional Adjustment of Input-Output Coefficients", *Environment and Planning A*, Vol. 12, No. 6, pp. 659-70.

19 Lecomber, J. R. (1969). "RAS Projections When Two or More Matrices Are Known", *Economics and Planning*, Vol. 9, No. 3.

20 Lynch, R. G. (1986). "An Assessment of the RAS Method for Updating Input-Output tables", in Ira Sohn (ed.), *Readings in Input-Output Analysis* (New York: Oxford University Press), pp. 271-84.

producing large errors, "analysts should always try to construct up-to-date input-output tables with actual, rather than with these estimated data, or they should make extensive adjustments to the data as they apply the technique."

- Although one of the criticisms of the RAS method is its relative simplicity, some other more complicated methods, such as linear and quadratic programming, have failed to show clear superiority relative to the RAS method (see Omar (1967)[21] and Bacharach (1970)[22]). Contrary to some claims that the RAS method "has been superseded by more recently developed entropy-theoretic methods," McDougall (1999) more recently found that the RAS method is itself an entropy optimization method. He showed that the RAS method is equivalent to maximizing a weighted sum of the column-coefficient cross-entropies, where the weights are row (or column) sum values. The RAS method can be seen as treating column and row coefficients symmetrically and is a special case of the cross-entropy method. Robinson *et al*. (2001) applied a cross-entropy method for updating and estimating a social accounting matrix, and subsequently echoed the finding by McDougall, stating that "the method represents a considerable extension and generalization of the standard RAS method." Such findings show that the RAS method, despite its simplicity and ease of implementation, should not be abandoned to other "newer" methods, particularly since there still seems to be more to learn about this method.

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21 Omar, F. H. (1967). The *Projection of Input-Output Coefficients with Application to the United Kingdom*, University of Nottingham, Ph.D. thesis.

22 Bacharach, M. (1970) *Biproportional Matrices and Input-Output Change,* Cambridge University Press, Cambridge, 1970.

Our review of the literature indicates that little attention has been given to the accuracy of the RAS method as a function of the level of industry aggregation used for updating and balancing I-O tables. In this paper, we intend to examine this issue in order to extend our understanding of the technique.

IV. Tests of Balancing Techniques

Our objective is to develop an automated, less labor-intensive method that is capable of producing a balanced annual I-O table with no loss of quality compared to the more labor-intensive method used at present. To meet this objective, we designed a set of tests to answer the following questions:

- Does balancing in both producers' and purchasers' prices improve results? Most I-O tables are balanced in producers' prices. However, balancing in producers' prices ignores the detailed estimates of final use expenditures from the NIPA's, which are valued in purchasers' prices, and the relationships between transportation and margin costs and the use of goods. We hypothesize that valuing in purchasers' prices and including detailed purchases from the NIPA's improves the reliability of our balancing model.
- Does the addition of known estimates of value added for industries improve our results? Value added makes up a significant portion of each industry's input structure. We hypothesize that providing estimates of value added for industries significantly reduces necessary adjustments and improves overall results.
- Does greater industry and commodity detail improve the results? The more aggregated the

table, the more diverse the mix of products grouped together as a single commodity and the more diverse the market; conversely, the more disaggregated the table, the more specialized the commodity and the more specific the market. We hypothesize that more detail at the working level improves the initial distributions of commodities to users and, consequently, also improves the validity of the balancing model.

To answer these questions we designed a set of twelve tests, using two different balancing models, three levels of detail, and with or without specifying value added for industries.

Balancing models. -- The tests identified for answering the questions are based on two different balancing models. The first is a basic model, which applies the standard bi-proportional technique for balancing an I-O use table. The second is an enhanced model, which expands the standard model to balance an I-O use table in both producers' prices and purchasers' prices. The enhanced model, because it includes transactions in purchasers' prices, allows the balancing procedure to include the final use expenditure categories included in the national income and product accounts (NIPA's).

Basic model. -- The basic model balances the use table in producers' prices. It begins with a use table that has been updated, following steps one through four described previously. The row controls are equal to the values for each commodity's output and the components of value added -- that is, compensation, indirect business taxes (IBT), and other value added (OVA).

The column controls are equal to the output values of total output for industries and the components of final uses including personal consumption expenditures (PCE), gross private fixed investment (GPFI), changes in business inventories, exports, imports, Federal defense consumption expenditures and investment, Federal nondefense consumption expenditures and investment, and State and local consumption expenditures and investment. All cells for changes in business inventories, exports, and imports, are fixed values and are not allowed to change. Additionally negative cells are not allowed to change because it is difficult to include negative cells in a balancing algorithm[23]. All other cells are allowed to adjust to fit the row and column controls.

The basic model balances the use table to row and column controls through an iterative process. For each iteration, the model begins with the rows, adjusting the row cells, such that their sum equals the row control total less the sum of fixed cells for the row. Next, the cells of the column are adjusted such that their sum equals the column control total less the sum of fixed cells. This process continues until the matrix is either balanced or approximately balanced. As a final step, any remaining difference between the sum of the row cells and the row control total is subtracted from the largest non-fixed cell in the row, and any difference between the sum of the column cells and the column control total is subtracted from other value added in the column.

Enhanced model. -- The second model, referred to as the enhanced model, balances the use table matrix in both producers' prices and purchasers' prices, the difference being transportation costs (rail, truck, water, air, pipelines, and gas pipelines) and margin costs (wholesale and retail). The

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23 The use table includes negative transactions in final uses. Most of these are in imports or changes in business inventories. When transactions are negative in other columns, these are generally either for sales of used goods from investment or the sales of general government services, such as public hospitals or public higher education, to other sectors.

allocations of these transportation costs and margin costs to industries and final uses are functions of how the commodities are moved by the transportation system and through the distribution channels. In the use table, these costs are summed for each industry and shown as separate commodity purchases. To provide valid estimates of transportation and margin costs used by industries, it is important to maintain these relationships.

The enhanced model satisfies these requirements. It includes ten matrices, each of which must be balanced internally, while maintaining specified relationships between matrices. Separate matrices are prepared for commodities valued in producers' prices and in purchasers' prices as well as for each of six transportation modes (rail, truck, water, air, oil pipe, and gas pipe), and for wholesale trade and retail trade margins. The transportation and wholesale matrices are of the same dimensions as the producers' and purchasers' price matrices. The retail matrix is a single vector of retail trade margins assumed to apply to all consuming industries and final users. The matrix valued in producers' prices and the matrix valued in purchasers' prices are related through the six transportation and two trade matrices. A cell in the purchasers' value matrix equals the respective cell in the producers' value matrix plus those in the transportation and trade matrices; conversely, a cell in the producers' value matrix equals the respective cell in the purchasers' value matrix less those in the transportation and trade matrices.

The controls for matrices of the enhanced model differ from those for matrices of the basic model. Since transportation and trade margin matrices have been separated from the producers' price matrix, we no longer have row and column control totals for each matrix. Each row in the producers' price, transportation, and trade matrices has separate control. Since the producers' price, transportation, and wholesale matrices are two-dimensional, there are separate row controls for each commodity. That is, for each commodity we have a separate control total for the commodity output valued in producers' prices, for each mode of transportation used to move that commodity, and for the wholesale trade margin used to distribute the commodity through the wholesale distribution system. The retail margin vector has only one control, which is the sum of the cell values. The purchasers' price matrix, since it is the sum of producers' price inputs plus transportation and trade margin costs, only has column controls for each industry and final use category.

The enhanced model begins with the same use table as the basic model with some modifications. First, separate matrices are created from the basic model to allow balancing of cells in producers' and purchasers' prices, as well as cells for transportation and trade as discussed above. Second, because we have detail in purchasers' prices for NIPA final use expenditure categories, we use this information as controls for final uses. Using this information, we expand PCE from one category to 126 categories; gross private fixed investment from one to 26; structures, from one to 30; and government expenditures and investment from six to 236. As with the basic model, some elements are fixed in all matrices, including exports, imports, changes in business inventories and all negative cells.

Balancing the enhanced model is complex and requires more steps than the basic model. For each iteration, the rows are balanced first. To balance the rows, adjustment factors are calculated, equaling the row output control less the sum of fixed cells, divided by the sum of the current values of the cells less any fixed cells. The row adjustment factors are then applied to the row cells in each of the matrices. Each cell in the matrix valued in purchasers' prices is then calculated as the sum of the adjusted producers' price cells plus the respective adjusted transportation and trade cells. To balance the columns, the column adjustment factors are calculated, equaling the column output control less the sum of fixed cells divided by the sum of the column cells less fixed cells. The column adjustment factors are then applied to the column cells in each of the matrices. The cells in the matrix valued in producers' prices are then calculated as the difference of the purchasers' price cells less the respective adjusted transportation and trade cells.

After a set number of iterations, and when the cells are close to being balanced in both producers' and purchasers' values, then the transportation and trade matrices are forced to balance to the respective row control totals. The balancing of the transportation and trade matrices is delayed until the matrices valued in producers' and purchasers' prices are approximately balanced in order to maintain the initial transportation cost rates and trade margin rates as long as possible.

Sizes of use tables. -- Our tests were designed to measure the effect of balancing various sizes of use tables. For the update of 1992 to 1997 three different sizes were tested: The published summary level (100 industries and commodities), the published detail level (500 industries and commodities), and the source data level (700 industries and 2300 commodities). (See table 1 for details).

The source data level is substantially more detailed than the other tables. The commodities and industries in this table are approximately at the same level of detail as for the source data. That is to say for industries the four-digit SIC level industries and for commodities the five-digit product class data for manufacturing and the four-digit level for all other commodities. This level of detail included the 431 final use categories. This table was updated to 1997 following the first four steps of the annual I-O process. The updated table was then collapsed to the level of industries and commodities required by the respective balancing models.

Value added tests -- Our tests of the impact of supplying known estimates of value added required two sets of value added estimates. The first set, consisted of the three components of value added from the respective benchmark I-O table updated by the change in real industry output. The updated value added components, with the exception of negative values, are included in the basic and enhanced models and are allowed to adjust while balancing to the respective row and column controls.

The second set of value added estimates began with the updated value added estimates from 1992 benchmark I-O accounts but were adjusted to agree with the 1997 published NIPA value added aggregates for all industries. The 1992 value added components were updated to 1997 using the change in real industry output, then adjusted to row controls for compensation, IBT and other value added. Value added components by industry were then adjusted such that the sum of the components equaled the I-O published value added. For this test the compensation and IBT were fixed and other value added allowed to adjust, if it was not negative.

Test results. -- The twelve different versions of the updated use table were balanced using the bi-proportional adjustment process. Each was balanced by running the model through 40 iterations of the row and column adjustment procedure described previously. The resulting use tables were then collapsed to the summary level for comparison. Each matrix was then compared to the published 1997 annual I-O use table.

Our measure of comparison was the direct coefficient. The fewer the differences in direct coefficients between the balanced tables and the published 1997 annual table, the better the balancing model. Our comparisons were limited to the larger cells of the use table, that is to say those intermediate and final use direct coefficients with a published producer value greater than $100 million, and to those cells with an absolute value difference in the direct coefficients (published less the balanced direct coefficient) greater than .01.

Based on our tests we found:

- The enhanced model produced fewer differences from the published direct coefficients table than the basic model.
- Increasing the level of detail always improves results.
- The addition of known value-added estimates significantly improved the results.
- The number of differences for all versions are relatively small.

At the summary level of detail, the number of differences from the published table ranges from 64 for the basic model, balanced at the source data level and with updated value-added estimates, to 39 for the enhanced model, balanced at the source data level of detail and with fixed value added estimates. (See table 2.) The number of differences is relatively small compared to the total 1,041 possible cells with large coefficients and with an error rate of between 3.7 percent and 6.1 percent.

For the more detailed tables (detail and source levels), the tables were collapsed to the published detail level and compared. The differences range from 371 for the basic model at the detailed level using updated value-added estimates to 184 for the enhanced model balanced at the source data level and using fixed value-added estimates. (See table 3.) In all cases, the results improved when fixed estimates for value-added are used, the more detailed source data are used, or when the enhanced model is used.

Comparisons were made for the characteristic differences between pairs of balancing models. These comparisons attempted to measure the specific improvements made by providing value-added estimates (see table 4), using the enhanced model rather than the basic model, (see table 5), and using the source data level of detail versus more aggregated estimates (see table 6).

For all tests, providing fixed estimates for value added almost always improves the results of the automated balancing (see table 4.) The number of coefficient differences declines and the average coefficient difference is lowered. The average coefficient differences remain at about the same level, around 3 percent.

Comparisons of the results from the enhanced model with the basic model shows that the number of differences declines when using the enhanced model (see table 5.) However, the average coefficient differences increase slightly when using the enhanced model. Comparisons of the effects of levels of detail shows that the number of differences declines when using the source level of detail (see table 6).

V. Conclusions and areas for further research

To produce tables that are more current and are capable of being revised quickly based on revised data, the U.S. annual I-O accounts require the development of automated techniques for balancing. The research presented in this paper demonstrates that automated balancing techniques, primarily using the bi-proportional adjustment method, produce reasonably good results.

Two versions of the bi-proportional model were tested. The research shows that the best results are obtained using the enhanced model, balanced in both producers' and purchasers' prices. It also shows that providing estimates of the components of value added significantly improves the results. Finally, the research shows that balancing at greater levels of detail improves the results.

While the models produce use tables that are similar to the published use table, the remaining differences are still important. Additional research needs to be done to evaluate these remaining coefficient differences and their causes..

Additional tests are required to test the reliability of the updating and balancing techniques presented in this paper on benchmark I-O tables. Preliminary work has begun on an update of the 1987 benchmark I-O table to 1992. This update will be balanced using the techniques discussed in this paper and compared to the 1992 benchmark input-output tables.

Table 1. – Comparison of Detail Maintained for the Basic Model and Enhanced Model

Level of Row and Column Detail	**Basic Model** (Balance in producers' prices)	**Enhanced Model** (Balance in producers' prices, transportation costs, margin and purchasers' prices)
Summary	100 industries 100 commodities 13 final use categories 3 value added categories	100 industries 100 commodities 450 final use categories 3 value added categories
Detail	500 industries 500 commodities 13 final use categories 3 value added categories	500 industries 500 commodities 450 final use categories 3 value added categories
Source	715 industries 2281 commodities 13 final use categories 3 value added categories	715 industries 2281 commodities 450 final use categories 3 value added categories

Table 2. -- Summary Level Large Coefficient Differences, Excluding Value Added

Balance model level of detail		Basic Model	Enhanced Model
Summary	Updated value added	53	63
	Fixed value added	49	46
Detail	Updated value added	61	48
	Fixed value added	52	43
Source	Updated value added	64	47
	Fixed value added	48	39

Note: Large coefficients are those greater than .01. Total number of large coefficients in the published 1997 use table is 1041.

Table 3. -- Detail Level Large Coefficient Differences, Excluding Value Added

Balance model level of detail		Basic Model	Enhanced Model
Detail	Updated value added	371	232
	Fixed value added	312	303
Source	Updated value added	264	232
	Fixed value added	207	184

Note: Large coefficients are those greater than .01. Total number of large coefficients in the updated 1997 use table is 3,168.

Table 4. – Large Coefficient Differences With and Without Value Added Estimates, 1992 to 1997 Update

Model	Balance Level	Value Added *	Number of Differences	Mean Absolute Value of Coefficient Difference	Number of Matching Cells	Mean Absolute Value of Matching Cell Coefficient Difference	Mean Absolute Value of Coefficients for Non-matching Cells
Basic	Detail	Updated	371	.027	265	.032	.015
		Fixed	311	.025	265	.027	.014
	Source	Updated	264	.030	180	.034	.021
		Fixed	207	.028	180	.030	.017
Enhanced	Detail	Updated	232	.032	192	.035	.017
		Fixed	303	.027	192	.029	.023
	Source	Updated	232	.033	163	.034	.029
		Fixed	184	.029	163	.030	.020

∗ Updated: Value added was undated and allowed o change during the bi-proportional adjustment process.
Fixed: Value added components updated, adjusted to published annual I-O level. Compensation and indirect business values were not allowed to change.

Table 5. -- Large Coefficient Differences Enhanced Model Versus Basic Model, 1992 to 1997 Update

Value Added	Balance Level	Model	Number of Differences	Mean Absolute Value of Coefficient Difference	Number of Matching Cells	Mean Absolute Value of Matching Cell Coefficient Difference	Mean Absolute Value of Coefficients for Non-matching Cells
Updated	Detail	Basic	371	.027	196	.035	.018
		Enhanced	232	.032	196	.034	.020
	Source	Basic	264	.030	183	.034	.019
		Enhanced	232	.033	183	.036	.019
Fixed	Detail	Basic	311	.025	243	.028	.015
		Enhanced	303	.027	243	.029	.017
	Source	Basic	207	.028	159	.031	.018
		Enhanced	184	.029	159	.031	.016

Table 6. –Large Coefficient Differences Between Detail and Source Levels of Detail, 1992 to 1997 Update

Model	Value Added	Balance Level	Number of Differences	Mean Absolute Value of Coefficient Difference	Number of Matching Cells	Mean Absolute Value of Matching Cell Coefficient Difference	Mean Absolute Value of Coefficients for Non-matching Cells
Basic	Updated	Detail	371	.027	206	.033	.019
		Source	264	.030	206	.033	.018
	Fixed	Detail	311	.025	187	.030	.018
		Source	207	.028	187	.030	.012
Enhanced	Updated	Detail	232	.032	192	.034	.023
		Source	232	.033	192	.033	.032
	Fixed	Detail	303	.027	169	.031	.022
		Source	184	.029	169	.030	.013