# The Statistical Reconciliation of Time Series of Accounts after a Benchmark Revision

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## Abstract

In this study the 2003-2007 U.S. annual input-output accounts, GDP-by-industry accounts and expenditure-based GDP are reconciled with the 2002 and 2007 quinquennial benchmarks and all contemporaneous constraints of the input-output accounts for the in-between years. The series are adjusted according to statistical procedures able to deal with large systems of accounts subject to both temporal and contemporaneous constraints. Our objective is to adjust the preliminary levels of the series such that they (i) are consistent with the quinquennial benchmarks available, (ii) fulfill all the accounting relationships for any given year, and (iii) show movements that are as close as possible to the preliminary information. To this end we use a simultaneous least-squares procedure based on the proportional first difference (PFD) criterion, a movement preservation principle proposed by Denton (1971). According to our past experiences, we evaluate the possible adoption of (i) a pure proportional adjustment (PROP) for series with breaks and high volatility that deteriorate the meaningfulness of growth rates and (ii) a priori constraints for groups of variables according to their different reliability, where this can reasonably be assumed.

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## 1. Introduction

Measurements of socio-economic phenomena are conducted at different frequencies, with different objectives. Monthly or quarterly information aims at providing a timely picture of the short-term movements. Annual data from sample surveys or administrative statistics from regulatory agencies rely on a large sample of units, and thus, they provide a more accurate indication of medium- and long-term trends than intra-annual data. The Economic Census collects most comprehensive data on business activities and provides a detailed and accurate portrait of the Nation's economy once every five years. Higher frequency measurements are generally required to match corresponding lower frequency benchmarks.

At each frequency, social-economic variables may be required to satisfy a number of aggregation and accounting relationships. A typical example is national accounts, where total aggregates of the economy must be consistent with the sum of detailed components (e.g. by industry or by commodity) and identities are established between flows of production, expenditure, and income. However, cross-sectional consistency between the observed variables is not automatically met and must be restored.

In a system that uses both low and high frequency series, observed data need to be adjusted such that both temporal and contemporaneous constraints are satisfied. A reconciliation process aims at preserving as much as possible the content of the preliminary information available. Because the time series dimension of socio-economic variables is relevant, it is often necessary that the short term movements (or the growth rates) of the preliminary information are preserved in the best possible way.

In a recent study (Chen *et al.*, 2013), a specific problem of reconciling annual (preliminary) estimates of U.S. national accounts aggregates subject to quinquennial benchmarks available from detailed Input-Output (IO) tables was addressed. Given preliminary, revised, but not fully balanced annual IO accounts from 1998 to 2002 and 2 revised and fully balanced IO accounts for benchmark years of 1997 and

2002, annual IO accounts for years 1998-2001 have been fully balanced and revised, where temporal profile of the preliminary aggregates was preserved as much as possible. The objectives were to adjust the annual data such that they (i) were consistent with the Quinquennial benchmarks available, (ii) fulfill all the IO accounting relationships for any given year, and (iii) show movements that are as close as possible to the preliminary information. A simultaneous least-squares procedure based on the proportional first difference (PFD) criterion, a movement preservation principle proposed by Denton (1971), was compared with a pure proportional (PROP) adjustment procedure.

The results showed that these objectives were best achieved through the least-squares procedure based on PFD criterion, because this procedure was able to smooth the differences observed between the preliminary and the benchmark data, reducing the impact of the correction by distributing it over all the years. However, it was also noticed that a PFD adjustment provides unsatisfactory results for a small subset of series that present breaks and changes from positive to negative values. Because these movements are difficult to preserve, they were adjusted according to a pure proportional criterion. It was shown that a constrained optimization procedure which minimizes a combined PFD-PROP objective function improves the overall adjustment of the system, minimizing the impact on the year-to-year changes of the preliminary series.

With the recent release of the 2007 benchmark IO tables in January 2014, in this study we apply the simultaneous constrained optimization procedures to reconcile the annual estimates of the U.S. national accounts aggregates from detailed IO tables from 2003 to 2007 subject to the quinquennial benchmarks from the 2002 and 2007 benchmark IO tables. The preliminary annual IO estimates are revised from the previously published IO tables but are not fully balanced. The benchmark IO tables are fully balanced. With the objectives outlined in the previous study, we wish to obtain revised and fully balanced IO accounts for years 2003-2006, where the temporal profile of the preliminary aggregates is preserved as much as possible.

The paper is structured as follows. Section 2 describes the construction of the U.S. benchmark IO tables and the revision of previously published annual IO estimates. Section 3 briefly introduces benchmarking and reconciliation of economic time series. Section 4 presents and evaluates the results achieved using a least-squares procedure based on alternative objective functions. Finally, Section 5 concludes the paper.

## 2. Construction and Revision of U.S. Input-output Accounts

The U.S. national accounts system measures gross domestic product (GDP) via production, expenditure and income approaches. For the system to be consistent, GDP measured as total value-added (VA) from the IO accounts must be consistent with GDP measured as total final expenditures from the national income and product accounts (NIPAs), which should also be consistent with gross domestic income (GDI) measured as VA from GDP-by-industry accounts.

The U.S. IO accounts consist of make and use tables and are classified by $N$ number of industries and $M$ number of commodities. Thus, the IO accounts must satisfy $N$ sets of industry and $M$ sets of commodities cross-sectional aggregation constraints each period. Because data used to compile IO accounts are obtained from a variety of sources, inconsistency often arises in the initial estimates due to differences in the definition and classification of some source data items and due to measurement errors in the source data. Consequently, initial data items of the IO accounts rarely satisfy all cross-sectional accounting constraints and consistency between components in the IO accounts must be restored.

Often individual series in the IO accounts must also add up to temporal benchmarks, and thus, must satisfy their respective temporal aggregation constraints. For example, each component series of quarterly GDP-by-industry must add up to its annual aggregates, and each component series in the annual IO accounts should be consistent with its corresponding quinquennial benchmarks. Quinquennial benchmark data, based primarily on Economic Census, contain more complete information and, thus, are more accurate, but they are not timely. Higher frequency source data, such as quarterly series for GDP-by-industry or annual surveys for the annual IO tables are timely but often contain incomplete information. Hence, they are less accurate; benchmarking or interpolation procedures must be employed to restore temporal aggregation constraints. To achieve consistency in the time series of IO accounts, cross-sectional and temporal aggregation constraints must be restored simultaneously.

The U.S. industry economic accounts (IEAs) benchmark IO tables are constructed every five years using data compiled primarily from Economic Census and Economic Census related surveys. Information from the benchmark IO tables is then incorporated in the comprehensive revision of GDP. For the following five years after the benchmark IO tables are constructed, annual IO tables are compiled using extrapolated data from the previous benchmark IO tables using annual surveys when available and data from other sources as indicators. Traditionally, after each comprehensive revision of GDP, previously published annual IO tables are revised and rebalanced according to the information from the benchmark revised GDP. However, annual IO tables were not reconciled with the benchmark IO tables prior to the 2007[5] comprehensive revision of the U.S. IEAs.

A key feature of the 2007 comprehensive revision is to fully integrate the benchmark IO tables with annual IO tables and with GDP from the NIPAs. For a detailed discussion, see Strassner and Wasshausen (2013). The 2007 benchmark make table was constructed using data primarily from the 2007 Economic Census, and estimates in the make table were considered predetermined and were not adjusted in the balancing of the benchmark IO tables. The initial benchmark use table for 2007 was prepared using data from a variety of sources. Initial estimates on intermediate inputs were based on business expenses from

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[5] As an initiative to achieve consistency in the time series IO accounts, during the 2002 comprehensive revision, the annual IO tables from 1998 to 2002 were reconciled with the 2002 benchmark IO tables and benchmark revised GDP. Nevertheless, they were not linked back to the 1997 benchmark IO tables. The reconciled tables were not published.

the Census Bureau. The initial estimates on final expenditures were prepared using data from the Census Bureau, the NIPAs, trade associations, private business and other federal government agencies. The initial VA estimates were based on data from the NIPAs, the Bureau of Labor Statistics, and the statistics of income (SOI) data from the Internal Revenue Services.

The construction of the 2007 benchmark use table takes two steps. In the first step, VA estimates from the balancing items in the use table were reconciled at 65-industry level of detail with VA estimates based on industry income data from the NIPAs using a pure proportional adjustment approach[6]. For details, see Kim *et al.* (2014). In the second step, the use table was balanced using a RAS procedure at a much disaggregated level of detail. RAS procedure sequentially adjusts the column and rows of the use table until the use table is balanced, subject to a set of predetermined marginal and aggregate constraints. The predetermined marginal totals include gross output by industry and by commodity from the make table, the final expenditures by category and by commodity from the NIPAs, and reconciled VA estimates in the first step of the balancing process. The balanced 2007 use table also satisfies the aggregation constraints that total VA from production across all industries equal total expenditures from the NIPAs.

To integrate annual and benchmark IO tables, the 2002 and 2007 benchmark IO tables were used as temporal benchmarks in the revision of the previously published annual IO tables. The 2002 benchmark use table was balanced using a weighted least squares approach[7] (Dylan *et al.* 2007). The 2002 benchmark IO tables were constructed according to the 2002 NAICS classification system and the 2007 benchmark IO tables were constructed according to the 2007 NAICS classification system. Thus, to have consistent elements in the temporal benchmark IO tables,

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[6] VA estimates from the NIPAs are compiled using company-based data, whereas VA estimates from IO accounts are compiled using establishment-based data. In the reconciliation, intermediate inputs and gross operation surplus (one of the 3 items in the VA estimate) were allowed to be adjusted according to the PROP approach.

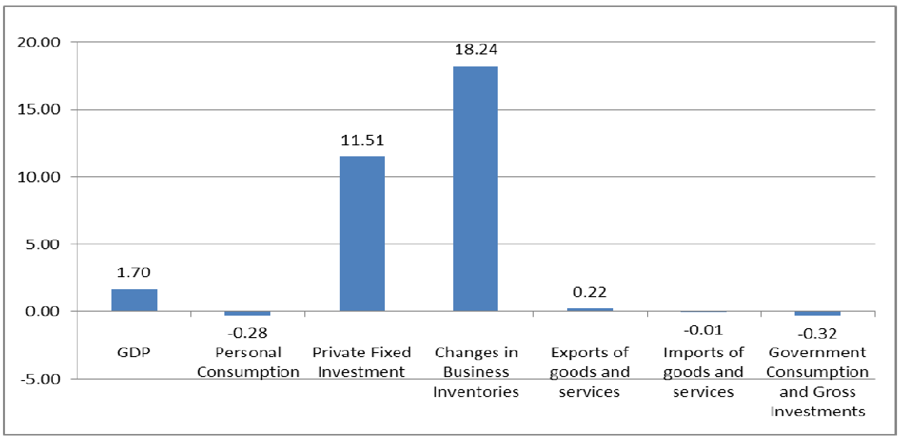
[7] The 2002 benchmark use table was balanced using a weighted least squares approach with weights being the absolute value of estimated standard deviation of the initial estimates. For details, see Rassier *et al.*, (2007).

some adjustments were made so that the 2002 benchmark IO tables are consistent with the 2007 NAICS classification system.

The revision of annual IO tables takes two steps. In the first step, the component series in the previously published annual make and use tables were adjusted according to the 2007 NAICS classification system. The component series in the make tables were then benchmarked to the quinquennial benchmark make tables using the proportional first difference Denton method (Denton 1971). In addition to the adjustments made for the consistency with the 2007 NAICS classification system, the component series in the previously published annual use tables were revised according to new information from the comprehensively revised GDP. In the second step, each annual use table was balanced using a RAS procedure. Taking as predetermined during the use table balancing process were gross output by industry and by commodity from the annual make tables, final expenditures by category and by commodity, and GDP from total final expenditures from the NIPAs.

Note that when a benchmark revision occurs, both level and growth rates of the variables in the IO tables are affected. Figure 1 shows the percentage revision produced by the 2007 benchmark estimates on the level of GDP and the major final uses aggregates. The impacts of 2007 benchmark revision ranges from -.32% for government consumption and investment to 18.24% of Changes in the business inventory, while the 2007 preliminary GDP level showed a 1.7% upward revision.

Figure 1: 2007 Benchmark Revisions of GDP and Final Uses by Major Category (% of preliminary 2007 values)



In this study, reconciliation is conducted at the level of detail of 65 industries, 69 commodities, 3 VA components and 11 final expenditure categories. The available preliminary data present temporal inconsistencies and accounting discrepancies (by industry, see Figure 2, and by commodity, see Figure 3). Discrepancies are in general small with a few outliers as seen in the figures.

Figure 2: Discrepancies (%) by Industry

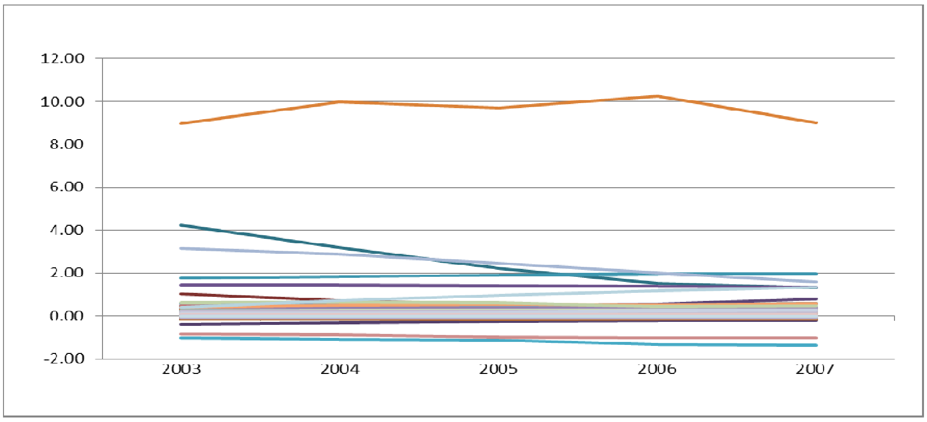
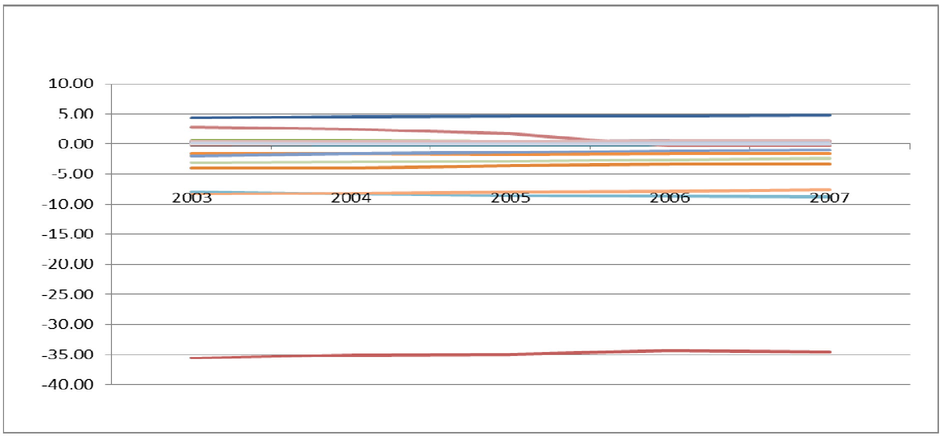



Figure 3: Discrepancies (%) by Commodity




At the chosen level of detail, the system of IO accounts consists of a total of 9924 series, 4485 from the make table and 5442 from the use table. Of the 4488 series from the make table, 801 are non-zero series, and of the 5442 series from the use table, the non-zero series include 3553 intermediate inputs, 193 VA and 294 final expenditures.

In the next section, we discuss how to deal with all these issues in a consistent statistical framework.

## 3. Benchmarking and Reconciliation of Time Series

To restore temporal constraints in each component series, the modified Denton’s proportional difference (PFD) benchmarking method (Denton, 1971; Helfand *et al.*, 1977; Cholette, 1984) has been implemented at the U.S. Bureau of Economic Analysis (BEA) since 2006. To restore contemporaneous constraints in the annual accounts, the usual reconciliation procedures use accounting identities from different parts of the system to reduce accounting discrepancies as much as possible and to record the residual between GDP and gross domestic income (GDI) as aggregate statistical discrepancy. In a recent study, a generalized least-squares (GLS) procedure is used to reconcile GDP estimates from IO, expenditures, and income accounts for a benchmark year according to the estimated reliabilities of initial source data items (Chen, 2012).

Consistency in the time series of the national account system requires that temporal and contemporaneous constraints be satisfied simultaneously. In recent years, two alternative reconciliation procedures have been introduced to restore temporal and contemporaneous constraints in a system of series (Quenneville and Rancout, 2005; Di Fonzo and Marini, 2011). The two-step procedures consist of a univariate process to restore temporal constraints in each components series. The two-step procedures are shown to be effective when low frequency benchmarks correspond to low frequency sums of the high frequency values (i.e. flow variables). However, each estimate in the quinquennial benchmark IO accounts pertains to the value of a variable at the end of the benchmark year, not the quinquennial sum of the values of the variable. In this case, the two-step procedure may not be able to preserve the temporal movements in each component series during the reconciliation process. What we need is a procedure that can simultaneous restore temporal and contemporaneous constraints in the annual IO accounts.

The reconciliation problem can be formalized in a compact matrix form as follows. The U.S. annual IO accounts consist of make and use tables. The 69x65 make table matrix contains the gross output of 69 commodities from 65 industries. The use table consists of a 69x65 matrix of intermediate inputs, a 3x65 matrix of industry value-added (VA) from industry income, and a 69x11 matrix of final uses.

Let $X_t$, $Z_t$, $V_t$, and $Y_t$ denote the matrices of preliminary estimates of gross output, intermediate inputs, value added and final uses in the annual IO accounts for t = 2003, …, 2007[8]. Let $\bar{X}_{2002}$, $\bar{Z}_{2002}$, $\bar{V}_{2002}$ and $\bar{Y}_{2002}$ denote the corresponding matrices for benchmark year 2002 and $\bar{X}_{2007}$, $\bar{Z}_{2007}$, $\bar{V}_{2007}$ and $\bar{Y}_{2007}$ for benchmark year 2007.

The preliminary matrices can be conveniently rearranged into a one-dimensional vector of stacked time series. Let $\mathbf{x}_{ij}$ denote the 6x1 column vector of the element (i,j) of the make table matrix $\mathbf{X}_t$, for t = 2002, …, 2007. We consider all (i,j) elements of the matrices even if they are zero's for all the years or for some years. There are 4,488 time series in the make table, which can be stacked into a single 26,910 x 1 vector as

$$\mathbf{x} = [x'_{2002,11} \;\; x'_{2002,12} \;\; \dots \;\; x'_{2002,65,69} \;\; \dots \;\; x'_{2007,11} \;\; x'_{2007,12} \;\; \dots \;\; x'_{2007,65,69}]' .$$

Vectors **z**, **y**, **v** can also be set up in the same fashion. Their row dimensions are 26,910, 4,554 and 1,170, respectively. The input vector of preliminary data of the problem is thus defined as

$$\mathbf{p} = [\mathbf{x}' \;\; \mathbf{z}' \;\; \mathbf{y}' \;\; \mathbf{v}']'$$

where vector **p** has row dimension of 59,544.

Let's now consider the constraints of the system. There are *exogenous* and *endogenous* constraints. The first type concerns the benchmark values for the years of 2002 and 2007. Let **b** denote the

[8] In order to link the reconciled series to the 2002 benchmarks, we consider the benchmark matrices of 2002 as part of the group of preliminary matrices as well.

vector of two-element time series from the benchmarked matrices previously defined, i.e.

$$\mathbf{b} = [\bar{x}^{(1,1)}_{2002}\ \bar{x}^{(1,1)}_{2007}\ \bar{x}^{(1,2)}_{2002}\ \bar{x}^{(1,2)}_{2007}\ \dots\ \bar{z}^{(1,1)}_{2002}\ \bar{z}^{(1,1)}_{2007}\ \bar{z}^{(1,2)}_{2002}\ \bar{z}^{(1,2)}_{2007}\ \dots\ \bar{y}^{(1,1)}_{2002}\ \bar{y}^{(1,1)}_{2007}\ \bar{y}^{(1,2)}_{2002}\ \bar{y}^{(1,2)}_{2007}\ \dots\ \bar{v}^{(3,64)}_{2002}\ \bar{v}^{(3,64)}_{2007}\ \bar{v}^{(3,65)}_{2002}\ \bar{x}^{(3,65)}_{2007}]',$$

with dimension of 19,848 x 1. Let $\mathbf{H_1}$ denote the 19,848 x 59,544 mapping matrix for the exogenous constraints specified in $\mathbf{b}$ for the benchmark years of 2002 and 2007. Given that, as we have previously said, preliminary and benchmark 2007 values are different, it is $\mathbf{H_1 p} \neq \mathbf{b}$.

The endogenous constraints are defined by the set of accounting identities defined by the IO tables. There are 69 row constraints (commodities) and 65 column constraints (industries) per year. The aggregation constraint of total GDP equals total VA is redundant and can be discarded, as it follows from adding up the first 134 constraints. The contemporaneous constraints for 1997 are redundant, because benchmarked estimates are used as the preliminary estimates. In total, they add up to 804 constraints for t = 2002, …, 2007. Let $\mathbf{H_2}$ denote the 804 x 59,544 matrix mapping 59,544 elements in the preliminary vector $\mathbf{p}$ to the 804 accounting constraints. Clearly, it is $\mathbf{H_2 p} \neq \mathbf{0}_{804x1}$.

In sum, we have

$$\begin{bmatrix}\mathbf{H_1}\\ \mathbf{H_2}\end{bmatrix}\mathbf{p} \neq \begin{bmatrix}\mathbf{b}\\ \mathbf{0}_{804x1}\end{bmatrix}, \tag{1}$$

and we wish to derive the 59,544 x 1 vector of reconciled values $\mathbf{r}$

$$\begin{bmatrix}\mathbf{H_1}\\ \mathbf{H_2}\end{bmatrix}\mathbf{r} = \begin{bmatrix}\mathbf{b}\\ \mathbf{0}_{804x1}\end{bmatrix}, \tag{2}$$

such that the temporal dynamics of $\mathbf{r}$ is 'closer' to that of $\mathbf{p}$.

To reconcile a system of time series, we use adjustment procedures based on the constrained optimization of two different objective functions:

- Proportional adjustment (PROP):

$$\sum_{i=1}^{n}\sum_{t=2003}^{2007}\frac{\left(r_{t,i}-p_{t,i}\right)^2}{|p_{t,i}|} \tag{3}$$

- Proportional First Difference (PFD) adjustment, which is a multivariate extension of the univariate benchmarking solution proposed by Denton (1971) and modified by Cholette (1984):

$$\sum_{i=1}^{n}\sum_{t=2003}^{2007}\left(\frac{r_{t,i}}{p_{t,i}}-\frac{r_{t-1,i}}{p_{t-1,i}}\right)^2 \tag{4}$$

where $n$ is the number of non-null variable of the system.

In both cases, the system is adjusted simultaneously (i.e. all variables and all years at the same time). However, the adjustment principles operate very differently. The PROP criterion distributes the differences proportionally to the levels of the variables. On the other hand, the PFD criterion preserves the year-to-year movements of the variables. Because out target is to preserve the changes in the preliminary variables, we expect that the PFD method provide more satisfactory results for this exercises.

We also define a combined objective function (see Bikker *et al.*, 2013):

$$\sum_{i\in S^{PFD}}\sum_{t=2003}^{2007}\left(\frac{r_{t,i}}{p_{t,i}}-\frac{r_{t-1,i}}{p_{t-1,i}}\right)^2+\sum_{i\in S^{PROP}}\sum_{t=2003}^{2007}\frac{\left(r_{t,i}-p_{t,i}\right)^2}{|p_{t,i}|} \tag{5}$$

where both the PFD criterion and PROP criterion are utilized. The variables in the system are divided in two subsets ($S^{PFD}$ and $S^{PROP}$, respectively): the PFD is used for those series showing meaningful and interpretable movements over time (namely movements that we would like to preserve), while for the rest of the series with breaks in the movements we switch to PROP[9]. We call this procedure PFD-PROP.

## 4. Results

In this study, we consider two sets of preliminary estimates in the reconciliation. The first set of preliminary estimates consists of the previously published annual IO tables from 2003 to 2007 with the necessary adjustments in order to be consistent with the 2007 NAICS classification system. The second set of preliminary estimates is the revised (as described in the previous section) and not balanced annual IO tables from 2003 to 2007. In theory, the previously published annual IO tables should be used directly as the preliminary estimates. However, in the actual production, the previously published IO tables were not directly used as preliminary estimates, because of changes in the classification system and new information from benchmark revision of GDP needed to be incorporated. We consider both sets of preliminary estimates in order to be able to compare the reconciled results using the least squares procedure with the annual IO tables recently released from the comprehensive revision of the U.S. industry economic accounts.

In order to assess the global performance of the procedures, for each series we calculate the Mean Absolute Adjustment (MAA) and the Root Mean Squared Adjustment (RMSA) to the percentage levels:

$$MAA_i^L = 100\ x\ \frac{1}{5}\sum_{2003}^{2007}\left|\frac{\hat{r}_{t,i} - p_{t,i}}{p_{t,i}}\right|$$

$$RMSA_i^L = 100\ x\ \sqrt{\frac{1}{5}\sum_{2003}^{2007}\left(\frac{\hat{r}_{t,i} - p_{t,i}}{p_{t,i}}\right)^2}$$

[9] In this exercise $S^{PROP}$ refers to changes in business inventories and to all other series presenting negative and positive values. They represent a small fraction of the series in the system.

and to the percentage growth rates:

$$MAA_i^R = 100\,x\,\frac{1}{5}\sum_{2003}^{2007}\left|\frac{\hat{r}_{t,i}}{\hat{r}_{t-1,i}} - \frac{p_{t,i}}{p_{t-1,i}}\right|$$

$$RMSA_i^R = 100\,x\,\sqrt{\frac{1}{5}\sum_{2003}^{2007}\left(\frac{\hat{r}_{t,i}}{\hat{r}_{t-1,i}} - \frac{p_{t,i}}{p_{t-1,i}}\right)^2}$$

for $i = 1, \dots, n$, where $n$ is the number of non-null series from the IO tables.

Table 1 shows the averages of indices MAA and RMSA calculated for 43 main aggregates of national accounts (gross domestic product (GDP), gross output, intermediate inputs and VA of 12 major industries, and 6 final expenditure categories). These aggregates are calculated from the detailed reconciled series derived using three reconciliation procedures:

- Proportional adjustment (PROP), minimizing criterion (2);
- Proportional First Difference (PFD) adjustment, based on criterion (3);
- Combined PFD and PROP adjustment (PFD-PROP), as defined by criterion (4).

Table 1: Summary measures of adjustment

| | **Levels** | | **Growth Rates** | |
|---|---|---|---|---|
| **Criterion** | $MAA^L$ | $RMSA^L$ | $MAA^R$ | $RMSA^R$ |
| PROP | 1.395 | 3.892 | 1.440 | 4.336 |
| PFD | 5.217 | 14.782 | 3.646 | 11.570 |
| PFD-PROP | 3.256 | 5.760 | 1.536 | 2.597 |

As expected, PROP minimizes the adjustment in terms of levels (both $MAA^L$ and $RMSA^L$ are minimum). Unexpectedly, PROP outperforms PFD in minimizing the adjustment in terms of growth rates. The PFD criterion is penalized by series in the system that present changes from positive to negative values (e.g. changes in business inventories). To overcome this difficulty, the PFD-PROP procedure adjusts all these series according to PROP while it maintains the PFD approach for the rest of the series. As it is noticed in Table 1, the PFD-PROP procedure achieves the minimum value for $RMSA^R$ .

Figure 3 displays the boxplots of $RMSA^L$ (top chart) and $RMSA^R$ (bottom chart) for the 43 aggregates (the absolute distance metric of MAA gives a less pronounced difference between the performance of the three procedures and it is not shown). The visual inspection of the boxplots confirm that PFD-PROP produces the smallest adjustment of the growth rates, while PROP provides the best results in preserving the original levels. As for the growth rates, this conclusion is evident looking at the RMSA statistics.

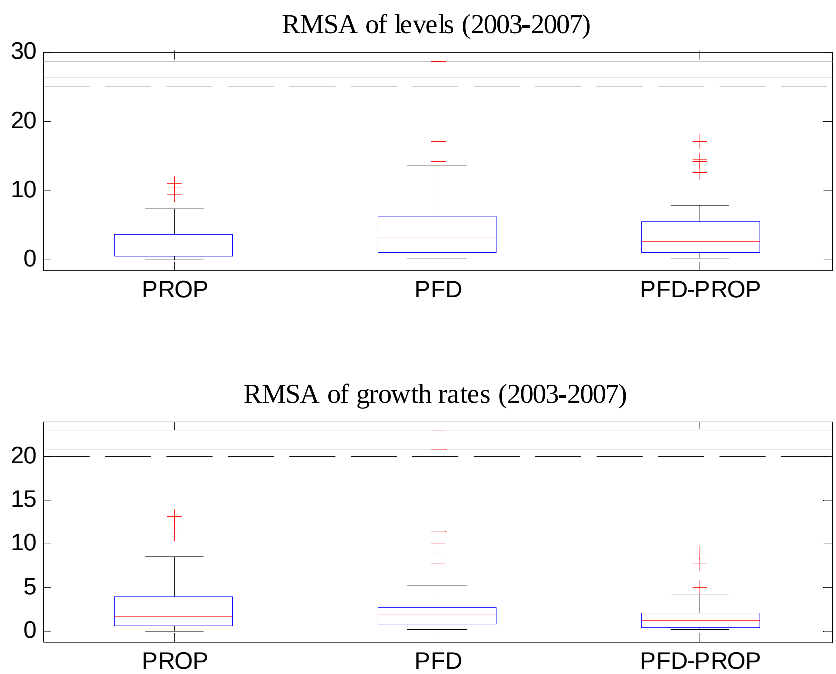



Figure 3: Boxplot of RMSA statistics

To understand the different type of adjustment conducted by PROP and PFD-PROP, it is useful to look at the treatment of some aggregate series, like GDP (Figure 4). The left-hand charts refer to the levels, the right-hand charts to the growth rates, and the adjustments to both levels and growth rates are shown in the bottom charts. It clearly appears that the adjustment done by PROP to GDP is all in the year 2007, differently from the reconciled estimates according to PFD-PROP, which produces (growing) adjustments to the levels for the entire period. This last feature permits to get 'smoothed' estimates of the growth rates, thus avoiding the abrupt 'jumps' produced by PROP, with a large positive correction of the preliminary 2007 growth rates.

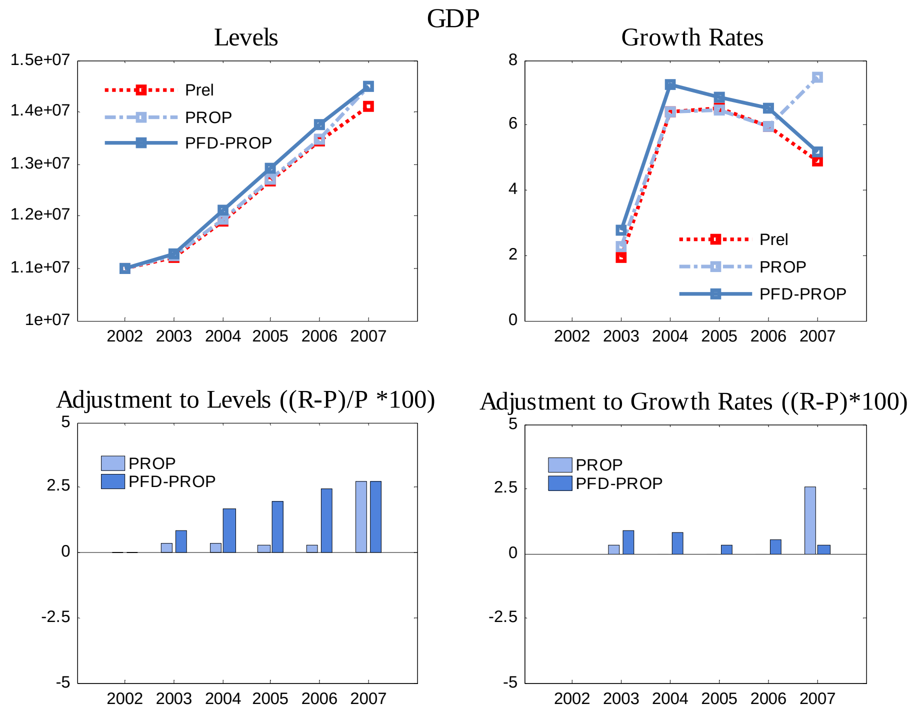



Figure 4: Gross Domestic Product: Adjustments to Levels and Growth Rates

## 5. Conclusion

In this paper we have shown how to reconcile annual preliminary series of national accounts with quinquennial benchmarks available from IO tables. Our objective was to minimize the impact of the adjustment on the movements in the preliminary series. In general, we have found that this objective is best achieved through a constrained optimization procedure based on a movement preservation principle, in our case the PFD criterion proposed by Denton (1971), modified by Cholette (1984). Looking at the temporal dynamics of the data, the PFD-based procedure is able to smooth the differences observed between the preliminary and the benchmark data of 2007, reducing the impact of the correction by distributing it over all the years.

However, we have noticed that a PFD adjustment provides unsatisfactory results for series that present breaks and changes from positive to negative values. Because these movements are more difficult to preserve, these series should be adjusted according to a pure proportional criterion. We have shown that a constrained optimization procedure that minimizes a combined PFD-PROP objective function improves the overall adjustment of the system, minimizing the impact on the year-on-year changes of the preliminary series.

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