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THE CASE OF ITALIAN SAM FOR YEARS 2005 AND 2010

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Riassunto
Questo lavoro analizza il livello di accuratezza nella proiezione di matrici di contabilità sociale, nella fattispecie di una matrice di contabilità sociale (SAM) in fase di proiezione della medesima. In particolare, l'utilizzo di una variante del metodo RAS standard consente di valutare l'effetto dell'applicazione di vincoli nella proiezione, aumentando la velocità del processo di riquadramento proporzionale. Un applicazione sviluppata in Visual Basic for Applications è stata applicata alla SAM italiana per gli anni 2005 (anno base) e 2010 (anno di proiezione).
Dopo una breve introduzione sul sistema dei conti nazionali, sulle matrici I-O e SAM, il capitolo 1 fornisce le basi metodologiche necessarie alla comprensione del metodo RAS e della variante implementata, trattata nel paragrafo 1.1, che fornisce inoltre alcuni brevi rimandi all'evoluzione storica del metodo. Il capitolo 2 presenta tabelle e grafici sui risultati principali, e le conclusioni propongono commenti e suggerimenti all'evoluzione dell'analisi.

Parole chiave: Metodo RAS, SAM, Bilanciamento vincolato, Visual Basic for Applications

Summary
This work deal with a variant of the classical method RAS used in predicting national accounts matrices like Social Account Matrix (SAM). It was demonstrate that taking into account the presence of constraint improves projection accuracy: the used variant provide an increasing speed in the balancing process and it was implemented by aVisual Basic for Application sroutine applied to data regarding the Italian Social Accounting Matrix (SAM) at 2005 (base year) and 2010 (projection year).
After a brief introduction on national account system and input - output and SAM, chapter 1 provide a methodological background focused on RAS method, while paragraph 1.1 outline a description of the used variant of standard method commented on the basis of available literature. Chapter 2 presents tables and graphs about main results, the conclusion provide some comments and suggestions for the improvement of the analysis.

Keywords: *RAS method, SAM, Constrained balancing, Visual Basic for Application*

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Introduction

This work was developed in the context of research activities focused on thesoft-linkage between technological models, such as MARKAL-TIMES, and macroeconomic models, such as CGEM and national accounts matrices like I-O or SAM[1].

A Social Accounting Matrix (SAM) is a conceptual framework to explore the effects of various exogenous shocks on changes in a socio-economic system based on its structural characteristics. Compared to input-output (IO) table, a SAM shows not only the inter-industry structure of the economy but the linkage between economic structure and income generation, distribution, redistribution and use by institutional sectors.
The SAM is constructed using a large number of statistical data sets that come from different sources,such as national accounts, trade data, input-output tables or supply-use tables, hencedata are often not consistent. Therefore, the datahaveto be made coherent.
In constructingand updating national SAM and IO tables, the RAS method has become a well-established technique. The traditional RAS approach requires that we start with a consistent SAM for a particular period and "update" it for a later period given new information on row and column sums.

The contribution of this paper is in presenting a RAS Variant with sectoral constraints and assessing the gain of the new method in terms of projectionaccuracy, quality and solution speed.
In order to test the new methodology a counterfactual analysis has been done using the Italian SAM for the year 2005 and the year 2010, provided by the University of Rome "Tor Vergata", department of economics and policy.

In order to introduce some basic concepts before the focus on the SAM, we remind that the System of National Accounts (U.N., A System of National Accounts, 1968)(U.N., System of National Accounts 2008), provides a way to represent a given economy and to define the inter-linkages between sectors. This conceptual approach dates from Quesnay and Walras and owes its formal arrangementto V. Leontief (Leontief, 1936).
In its very basic form, an Input–Output model is a system of linear equations, each one of which describes the distribution of a sector's product throughout the economy. In the scheme of so-called Input-Output matrix, the sectors are conventionally represented allocating the value added composition by column input and the sales by row(Miller & Blair, 2009).

To introduce the reader to the basic concepts required, we propose an elementary explanation of the nature and mechanics of an input output table.

An Input–Output model is constructed from observed data for a particular economic area – a nation or a region. The economic activity in the area must be able to be separated into a number of segments or producing sectors.

[1]Convenzione tra il Ministero dello Sviluppo Economico – Dipartimento per l'impresa e l'internalizzazione "Direzione Generale per la politica industriale e la competitività" (MiSE – DGPIC) l'Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile(ENEA) per la realizzazione delle attività di ricerca, studio e analisi finalizzate a supportare sul piano tecnico scientifico le azioni di competenza del Ministero per lo: " Sviluppo di metodologie innovative per l'analisi quantitativa dell'impatto sul sistema produttivo nazionale delle misure di riduzione delle emissioni di CO_2".

Let's suppose that in our simple model exist only three economic sectors: **Agriculture** (which produces and sells wheat and consumes cloth and labor), **Industry** (which produces and sells cloth and consumes wheat and labor), **Households** (that sells labor and consumes wheat and cloth).
It's important to make the distinction between *intermediate* consumption and *final* consumption: those necessary for production are defined intermediate goods/services[2], the others are final consumption (e.g. households that consume wheat).

This simple economic system can be represented by a flows matrix. Rows report what each branch sells to all other branches (including itself); columns report what it buys from other branches

Table 1– Inter-sectoral table - Simplified model for a 3-sector economy (physical units)

	Agriculture	**Industry**	**Households**	**Total**
Agriculture (1000kg of wheat)	7.5	6	16.5	30
Industry (meters of cloth)	14	6	30	50
Households (man-year of work)	80	180	40	300

• Agriculture produces 30000 kg of wheat, of which 7.5 consumed by it (e.g. seeds), 6 by Industry and 16.5 by Households.

• Industry produces 50 meters of cloth, of which 14 are consumed by Agriculture, 6 by itself, and 30 by Households;

• Households provide a total of 300 man-years: 80 to Agriculture (farmers), 180 to Industry (workers) and 40 to themselves (Housework).

• Agriculture employs 7500 kg of wheat, 14 meters of cloth - and 80 man-years to produce 30000 kg of wheat:

• Industry employs 6000 kg of wheat, 6 meters of cloth and 180 man-years to produce 50 meters of cloth;

• Households spend their income from employment (equivalent to 300 man-years of work) to buy 16500 kg of wheat, 30 meters of cloth and 40 man-years of work.

Why there are no column totals? For the reason that the values measured by column are physically inhomogeneous (kg of wheat, yards of fabric, man-years of work).
Then, needs a price system that ensures the effective possibility of trade between the different sectors (as well as the aggregation and comparison between the sum of rows and columns): in the case of Table 1 let's say that prices are:

20 euro per 1000 kg of wheat,

[2] Factors of production (labour, capital, land) and other inputs in the production of a specific good.

15 euro per one meter of cloth,
3 euro for a man-year of work.

Now wecan get the following table, multiplying the quantities of Table 1 for the selected prices.

Finally, we get the following table:

Table 2 - Simplified model for a 3-sector economy (currency units)

	Agriculture	Industry	Households	Total
Agriculture	150	120	330	**600**
Industry	210	90	450	**750**
Households	240	540	120	**900**
Total	**600**	**750**	**900**	**2250**

The mathematics of an input-output matrix is straightforward, but the data requirements are massive since the expenditures and revenues of each branch of the economy have to be represented. Nevertheless the Input-Output methodology is a useful tool for assessing economic impacts of policies and for investigating production relations among primary factors, intersectoral flows, final demands, and transfers.

1. Methodological background

"*Economics accounting is based on a fundamental principle of economics: for every income or receipt there is a corresponding expenditure or outlay. This principle underlies the double-entry accounting procedures that make up the macroeconomic accounts of any country. A SAM is a form of single-entry accounting. SAMs also embody the fundamental principle, but they record transactions between accounts in a square tableau or matrix format*(J. F. Francois, 1997).
The Social Accounting Matrix (SAM) is a matrix that compiles all the monetary flows among agents and sectors from a particular economy. It is a systematic method of representing the flows of goods/services and factors and the corresponding payments in an economic system (Stone & Brown, 1962).
With a social accounting matrix we can perform other type of investigations not allowed using the I-O tables (Miller & Blair, 2009).
SAM's were originally developed in Cambridge, UK, by R. Stone (Stone, 1962).The first SAM in 1962 was built as a matrix representation of the National Accounts, and was adopted by the World Bank with Graham Pyatt in the 1960s (Pyatt had worked for Richard Stone at the Cambridge Growth Project). Pyatt left Cambridge and "developed SAMs, mainly at the World Bank",

becoming together with Erik Thorbecke, the leading proponents and developers of SAMs. "*By the early 1980s, CGE models were heavily ensconced as the approach of the World Bank for development analysis. Social Accounting Matrices (SAMs) were similarly a mainstay of Bank analysis, which had been adopted as a presentational device by the CGE modellers*" (Mitra-Kahn, 2008).

SAM is a square matrix of data (number of columns equals number of rows) in the sense that all agents (agents typically include industries, factors of production (e.g. labor and capital), household consumers, the government and the rest-of-the-world region[3]) are both buyers and sellers. Every economic agent in the economy has both a column account ad a row account. Columns represent buyers (expenditures) and rows represent sellers (receipts).

SAMs were created to identify all monetary flows from sources to recipients, within a disaggregated national account. The SAM is read from column to row, so each entry in the matrix comes from its column heading, going to the row heading. Finally columns and rows are added up, to ensure accounting consistency, and the sum by column equals the sum of each corresponding row.

As shown in the following Table 3, in the SAM each cell represents a flow of funds from a source (column) to a recipient (row). It includes information from most transactions, such as the wages firms pay to households, household's consumption of goods, and taxes and transfers administrated by the Government.

Table3 - SAM for Open Economy

	Activities	**Commodities**	**Factors**	**Households**	**Government**	**Savings and Investment**	**Rest of world**	**Total**
Activities		Domestic supply						Activity income
Commodities	Intermediate demand			Consumption spending (C)	Recurrent spending (G)	Investment demand (I)	Export earnings (E)	
Factors	Value-added							Total factor income
Households			Factors payments to households		Social transfers		Foreign remittances	Total household income
Government		Sales taxes and import tariffs		Direct taxes			Foreign grants and loans	Government income
Savings and Investment				Private savings	Fiscal surplus		Current account balance	Total savings
Rest of world		Import payments (M)						Foreign exchange outflow
Total	Gross output	Total supply	Total factor spending	Total household spending	Government expenditure	Total investment spending	Foreign exchange inflow	

Now let's look ata simple example to highlight the differences between the I-O and SAM accounts representation framework (Miller & Blair, 2009).

[3] Rest-of-the-world region supplies imports and demands exports.

Table4 - I-O and SAM tables from Miller and Blair (2009)

Table 4.
Input – Output representation

	Nat. Res.	Manuf.	Services	Households	Total Output
Natural Resources	50	30	0	60	140
Manufacturing	60	40	40	40	180
Services	0	0	0	100	100
Value Added					
Labor	10	70	10		
Capital	20	40	50		
Total Inputs	140	180	100		

Table 5.

SAM Framework Example Using Social Accounting Conventions

	Expenditures						
	Nat. Res.	Manuf.	Services	Labor	Capital	Households	Total Output
Income							
Natural Resources	50	30	0			60	140
Manufacturing	60	40	40			40	180
Services	0	0	0			100	100
Value Added							
Labor	10	70	10				
Capital	20	40	50				
Households				90	110		
Total Inputs	140	180	100	90	110	200	

Source: Miller and Blair 2009.

In the SAM framework, we consider a much more detailed picture of the economy including not only the input–output table of inter-industry income and output, but also the institutional income and expenditures associated with final demand and value added sectors. The SAM framework also provides essentially a complete accounting of the circular flow of income and expenditure in an economy.

SAMs can be easily extended to include other flows in the economy, simply by adding more columns and rows, once the Standard National Account (SNA) flows have been set up. Often rows for ‘capital’ and ‘labour’ are included, and the economy can be disaggregated into any number of sectors. Each extra disaggregated source of funds must have an equal and opposite recipient. So the SAM simplifies the design of the economy being modelled.

SAMs are currently in widespread use, and many statistical bureaus, particularly in OECD countries, create both National Accountsand this matrix counterpart. A theoretical SAM always balances, but empirically estimated SAM’s never do in the first collation. This is due to the problem of converting national accounting data into money flows and the introduction of non-SNA data, compounded by issues of inconsistent national accounting data (which is prevalent for many developing countries, while developed countriestend to include a SAM version of the national account, generally accurateto within 1% of GDP).

This was noted as early as 1984 by Mansur and Whalley, and numerous techniques have been devised to ‘adjust’ SAMs, as “inconsistent data estimated with error, [is] a common experience in many countries”. The traditional method of balancea SAM is based on an iterative process that adjusts each individual cell until the row and column totals became equal.

The RAS method is the most widely known and commonly used automatic procedure for balancing an Input – Output matrix[4]: this chapter gives a formal description of such a procedure (J. F. Francois, 1997). As expected, there is considerable literature reference on the RAS method, either as part of a more general class of mathematical procedures, both as an economic statistics method (Di Palma, 2005).

The amount of statistical information required for the construction of an input-output table is significant: calculations are complex and laborious, processing time is considerable and so national statistics institutes generally perform this kind of work only every 4-5 years. The methods and evaluation procedures are extremely variable; a series of continuous operations and harmonization are performed from time to time in a patient mosaic work, using all available statistical data.

The general methodology can be summarized in the following phases: firstly, it is necessary to evaluate the "marginal totals" of the table, i.e. the sum of rows and columns of the intermediate flowsmatrix: this involves the construction, for each branch, of the goods and services equilibrium account, the production account and the value added distribution account.

This work starts from the evaluation of the supply flows, namely for each sector the production $\mathbf{x_j}$ and the imports $\mathbf{m_j}$, and then the value added **Vj**, the total intermediate inputs ($\mathbf{x_j}$ and $\mathbf{m_j}$) and components of final demand (Consumption **C**, Investment **I**, Export **E**); then, we proceed to determine the matrix of intermediate flows, which is processed by line, by analyzing by row the sales of intermediate goods and services and by column the cost structure.

The RAS method requires knowledge, for each branch, of the row totals $\mathbf{x_{i.}}$ and of the column total $\mathbf{x_{j.}}$ of intermediate outputs and inputs of goods and services: such information can be determined by knowing the totals of the "frames", namely the final demand, the intermediate consumptions and the production level. The method also requires the knowledge of a whole matrix at the base year. Generally it is possible to assess directly the majority of the flows of intermediate goods and services, as soon as the necessary data become available. In this case, the application of the RAS method is limited only to the remaining entries.

The method is based on the assumption that the evolution of technical coefficients (see note 5) over time is due to the following factors:

• the price level of the production sector, i.e. the system of relative prices;

• the degree of "absorption" for each good, or the intensity with which a given good has been replaced by (or replaces) other intermediate goods as inputs in the production processes;

• the degree of production of each good, i.e. the use of an intermediate input in the production process, as a share of the total of intermediate inputs.

The three above mentioned factors are supposed to operate in uniform way: the first acts of each row and each column, the second on each row and the third on each column of the matrix. To take account of the influence of the above factors it operates in the following way:

First of all the technical coefficients will be corrected to take into account the changes in relative prices. Each technical coefficient of the economic table referredto the year of construction of the matrix (a_{ij}^0) will be multiplied by the ratio between changes (from the reference year) of the prices of the sectors i and j[5]:

[4]It is curious to note that the RAS acronym is generally explained using the name of the economist sir Richard Stone (1919–1991) but this is a matter of debate.

[5] We have:

$$a_{ij}^0 = \frac{x_{ij}}{x_j}$$

the same ratio with the update prices is:

1 $a_{ij}^{*} = a_{ij}^{0} * \frac{p_i}{p_j}$

Using matrix notation we can write:

2. $A^{*} = \hat{p} A_0 \hat{p}^{-1}$

where: $A_0 is\ t\square e$ technical coefficients matrix of the base year $A^{*}\ ist$technical coefficients matrix modified from price effect $\hat{p}$diagonal matrix of the price index between base year and update year $\hat{p}^{-1}$inverse matrix of the above diagonal matrix Then we must take into account the system modification due to changes in the absorption (r) and fabrication (s) degrees of each good[6]. To perform this, each technical coefficients modified in the previous step, a_{ij}^{*}, will be multiplied for (r) and (s). In matrix notation we can write: $A_t = \hat{r} A^{*} \hat{s}$where: A_t is the technical coefficients matrix modified from (r) and (s) effects on each good $\hat{r}$ is the diagonal matrix that take account of the variations in the sales (r), A^{*} is the diagonal matrix of the price index between base year and update year and $\hat{s}$ diagonal matrix that take account of the variations in the fabrication processes (r) The updated coefficients can be writing as follow:

3. $a_{ij}^{t} = r_i (a_{ij}^{*}) s_j$

Substituting a_{ij}^{*} with$\left(a_{ij}^{0} \frac{p_i}{p_j}\right)$ we have:

4.$a_{ij}^{t} = r_i \left(a_{ij}^{0} \frac{p_i}{p_j}\right) s_j$

And, then the new value added coefficients:

1. $v_j = \left[1 - \sum_{i=1}^{n} r_i \left(a_{ij}^{0} \frac{p_i}{p_j}\right) s_j\right]$

The elements of (r) and (s) matrix are obtained by an iterative procedure based on a set of economic variables at the base year: X gross production, M imports of goods and services, V value added at factors cost, T indirect taxes, C public and private expenditures, I gross investment, E exports of goods and services. On the base of the above dataset, we determine the totals of purchases and sales of intermediate goods, and the marginal distributions of the table:

6. $u_i = [(X_i + M_i) - (C_i + I_i + E_i)]$

7. $z_j = \left[X_j - \left(V_j + T_j\right)\right]$

$a_{ij}^{*} = \frac{x_{ij} p_i}{x_j p_j}$
that demonstrates the above expression.

[6] See (Mesnard, 2002).

where: u_i IS sales of goods and services of sector i to other sectors z_j purchases of goods and services of sector i from other sectors. Calculation of the above vectors starts from the matrix (A^*) multiplied by the production vector with respect to the constraint represented by U, until the iterative process, after a certain number of steps, gives (r) and (s). Formally, at year t:

8. $A_t * X = u$

9. $\hat{X}A_t^{'} * I = z$

Where the symbols are already defined and I is the identity vector.

A_t matrix is obtained by A^* as follow:

10. $A^* * X = u_0$

Generally $u_0 \neq u$: to get the second term equal to $\underline{u}$ both terms are divided by u_0 and multiplied times$\underline{u}$; so:

11. $(\hat{u}\hat{u}_0^{-1}A^*)X = u$

The product $(\hat{u}\hat{u}_0^{-1}A^*)$ is a further correction of the original matrix A_0: we can satisfy the other condition ($\hat{X}A_t^{'} * I = z$) operating:

12. $\hat{X}\left(A^{'*}\hat{u}\hat{u}_0^{-1}\right)I = z_0$

Normally $z_0 \neq z$ and to get the equality between the two expressions we divide both the terms by z_0 then multiply them times z. We get:

13. $\hat{X}\left(\hat{z}\hat{z}_0^{-1}A^{'*}\hat{u}\hat{u}_0^{-1}\right)I = z_0$

At this point, A can be used as correct matrix and the iteration givesa new vector of sales:
14.$(\hat{u}\hat{u}_0^{-1}A^*\hat{z}\hat{z}_0^{-1})X = u_1$

then:

14. $(\hat{u}^2\hat{u}_0^{-1}\hat{u}_1^{-1}A^*\hat{z}\hat{z}_0^{-1})X = u$

repeating 13:

15. $\hat{X}\left(\hat{z}\hat{z}_0^{-1}A^{'*}\hat{u}^2\hat{u}_0^{-1}\hat{u}_1^{-1}\right)I = z_1$

To match with the z vector we have:

16. $\hat{X}\left(\hat{z}^2\hat{z}_0^{-1}\hat{z}_1^{-1}A^{'*}\hat{u}^2\hat{u}_0^{-1}\hat{u}_1^{-1}\right)I = z$

After (k+1) iterations, for sales and purchases vectors, the follow relationships are obtained:

18. $\left(\hat{u}^{k+1}\hat{u}_0^{-1}\hat{u}_1^{-1}\dots\hat{u}_k^{-1}A^*\hat{z}_0^{-1}\hat{z}_1^{-1}\dots\hat{z}_{k-1}^{-1}\right)X = u$

19. $\hat{X}\left(\hat{z}^{k+1}\hat{z}_0^{-1}\hat{z}_1^{-1}\dots\hat{z}_k^{-1}A'^*\hat{u}^{k+1}\hat{u}_0^{-1}\hat{u}_1^{-1}\dots\hat{u}_k^{-1}\right)I = z$

Fixing an appropriate threshold, the iteration process will converge to a finite solution.

At the last iteration, the resultingmatrix will be as follows:

20. $(\hat{u}^{k+1}\hat{u}_0^{-1}\hat{u}_1^{-1}\dots\hat{u}_k^{-1})A(^*\hat{z}^{k+1}\hat{z}_0^{-1}\hat{z}_0^{-1}\dots\hat{z}_k^{-1}) \cong A_t$

The r and s vector will be calculated by the following expressions:

21. $\hat{r} \cong \hat{u}^{k+1}\hat{u}_0^{-1}\hat{u}_1^{-1}\dots\hat{u}_k^{-1}$

22. $\hat{s} \cong \hat{z}^{k+1}\hat{z}_0^{-1}\hat{z}_1^{-1}\dots\hat{z}_k^{-1}$

The iteration process continues until the totals between rows and columns display an acceptable difference margin, an adequate correspondence threshold error between the two vectors. The research on iterative proportional fitting procedures was firstly related to a probabilistic class of problem in the first half of the last century (Deming & Stephan, 1940), then extended to a several mathematical class of problem and finally demonstrated (Fienberg, 1970) .

1.1 The implemented variant for the case study

Application of a modified version of the standard RAS method is not unusual (Jian, 2002). The used method fall in the so-called category of "*biproportion with Known Interior Information methods*" (Lahr & De Mesnard, 2004).The proposed variant follows the standard method about the object of the projection, that is the base matrix (applied on the flows and not on the coefficient) without further elaboration (Heng TOH, 1998). The analysis was focused only on historical data of Italy SAM for years 2005 and 2010 and hasn't involved any type of simulation, like those from bootstrap or Monte Carlo techniques (Jian, 2002) or from the problem of ranking the data quality in estimation (Rodrigues, 1014), since the main focus was to obtain a first order assessment of accuracy gain like a specific type of "constraints configuration".

The implemented variant for the canonical algorithm used,get the solution in two steps, excluding the cases in which indirect "undesired blocks"to other sectors respect the selected ones (typically when such a sectors contains all zeros but the rows/columns in common with the blocked ones) stop the balancing.

The algorithm doesn't use a specific treatment of zero in the blocking system or in the rest of the matrix in order to incorporate known information (Paelinck & Waelbroeck, 1982). The logical scheme is based on a sort of two-stage RAS: from this point of view point, the used variant appears similar to TRAS method, (Gilchrist & St. Louis, 1999)

First of all, a RAS method simple variant has been implemented and applied starting from the Italian SAM for the year 2005 to obtain the 2010 Italian SAM. In particular, using these data we have assumed unknown the intersectoral flows, taking as known only the row and column totals and the total value of the production at the projected year.

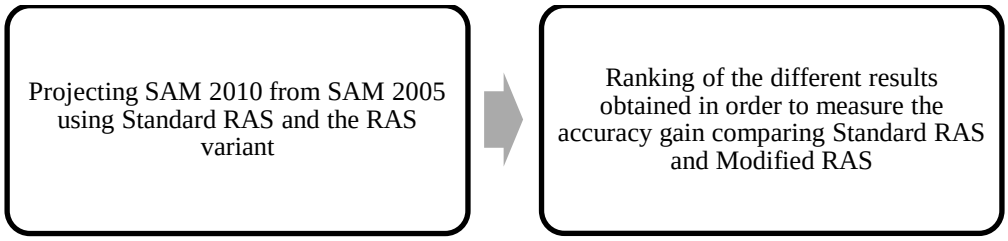
Next, three distinguished procedure that can be identified as "row-type", "column-type" and "cross type" has been applied. The procedureinvolves the execution ofthe RAS modified method using different set of constraints, blocking the entire cell on the rows, on the columns and on both the rows and the columns for each sector. Finally, it was performed a balancing process blocking a groups of sectors in the "cross-type configuration"and the results obtained from the different balancing were compared.

It must be noted that the "total lock" for a sector is not possible in all cases (particularly when the block of rows and cells does not coincide with the new estimated value for the total, also if only for the row or the column).

The program was created in an .xlsm file, using a set of routines developed in Visual Basic for Applications[7] (see Appendix 2 for the code) under the following logical work-scheme:

[7]Also using a code previously developed in VBA/GAMS to update an I-O table for Italy (Rao & Tommasino, 2014).

Figure 1 - Logical work scheme of the analysis



The constraint systemshave beenpracticallyimplementedby means of twodifferent routines:

1. the first creates and appliesthe constraints to the matrix, by highlighting the blocked cells with a color

2. the second performs the modified RAS(the procedure "reads" the color in each cell and "blocks" the colored cell that contain the constraints)

At the operationallevel, the algorithm, after the canonic first iterative step provided by RAS method, performsthe following operations:

1. the **difference** between the new total obtained by RAS iteration and the objective total (by row or by column) is calculated;

2. the **number** of the available free cells and their **sum** is calculated

3. the **share of the difference** assigned to each free cell on the basis of the proportion on the free cell sum represented by each cell is now added to the coefficient/flows calculated by RAS

Steps from 1 to 3 involve a simple add to the basic RAS formulas like:

23. $a_{ij} = a_{ijRAS} + diff * s_{FrC}$

Where:

a_{ij} is the estimated final coefficient/flows

a_{ijRAS} is the coefficient/flows estimated by RAS

$diff$ is the difference between the new total by RAS iteration and the objective total (by row or by column)

$s_{FrC}$is the share of a_{ij} on total free cell sum

To illustrate the speed gain by the use of the modified procedure, consider the following example, relating to the proportional fitting of a line with only three cells:

Figure 2– An intuitive example of the speed gain in iterative proportioning between standard RAS and the used variant

RAS

	CELLS			OLD	NEW
	3	5	2	10	20
STEP		**NO CONSTRAINTS**			
1	6	10	4		20
	WITH CONSTRAINTS				
1	3	10	4		17
2	3	11,76471	4,705882		19,47059
3	3	12,08459	4,833837		19,91843
4	3	12,13408	4,853633		19,98771
5	3	12,14154	4,856616		19,99816
6	3	12,14266	4,857064		19,99972

RAS VARIANT

	CELLS			OLD	NEW
	3	5	2	10	20
STEP					
					RESIDUAL
1	3	10	4	17	3
	FREE CELL SHARE ON TOTAL	71%	29%		
	RIPROPORTIONING OF RESIDUAL DIFFERENCE BY THE SHARE OF TOTAL VALUE OF THE FREE CELLS				
2	3	12,14	4,857	20	

As table 1 shows, without constraints, the standard RAS method fits the row in one step; with the constraints, the variant is balanced in 2 step, while the pure RAS requires at least 5-6 step to obtain an acceptable fit: clearlythe required number of iterations is directly correlated with the selected threshold.

The used threshold in the analysis was fixed at 5 million euros[8] (total threshold: 0,00007% of total value of 2010 SAM).

The main criticalities of the variant consists in the fact that, each time the constraints application involves the total block of a row (and a/or a column), there is the possibilites that no solution is available.For example, if, blocking two sectors, another sector hasall the remaining cells (except those related to the blocked sector)set to zero, the balance will be possible only in the case of the new total and the old total results are equal. This is related also to the value of the threshold.

To give a look of the abovementioned situation, see figure below:

[8]The threshold was fixed at a rather high level, in order to allow the evaluation of different economic activity sector that otherwise would not be assessable.

Figure 3–An example of infeasibility in balancing adding constraints by row - Projection of Italy SAM 2005 to 2010

2005	LAV	CAP	FAM	IMPR	AGR	SILV	EFFECTIVE TOTAL	NEW TOTAL	DIFFERENCE
LAV	0	0	0	0	7	0	636	617	19
CAP	0	0	0	0	19	0	748	726	22
FAM	617	400	274	331	0	0	1950	1950	0
IMPR	**0**	**326**	**0**	**0**	**0**	**0**	**419**	**610**	**190**
AGR	0	0	14	0	2	0	53	52	2
SILV	0	0	0	0	0	0	2	2	0
…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…
Totale	**617**	**726**	**1.950**	**610**	**52**	**2**	…	…	…
	617	**726**	**1.950**	**610**	**52**	**2**	…	…	…

Figure 3 shows an excerpt of the matrix related to a case occurred in projecting Italy SAM of year 2005 to year 2010 at the moment of blocking FAMIGLIE sector. Looking at the intersection of CAPITALE and IMPRESE: balancing CAPITALE by column (726 billion) involves the impossibility of row balancing for IMPRESE (the other value on the IMPRESE row are equal to 0; only the sell to GOVERNO sector is available to fitting procedure; but the selected method, based on conservative criteria, unable this cell to compensate the total difference residual, that is in the order of 200 billion of euros). The only value available and useful to balance, cell at the intersection of CAPITALE and IMPRESE (326 billion of euros) do not compensate simultaneously IMPRESE by row and CAPITALE by column.

This kind of problem occur when a cell have to be set to a value that balance by row totally different respect to the one needed to balance by column. This type of situation can be overcome only when the difference is very small (in the order of some million of euros), while in some cases the difference can be assume values around an hundred billions of euros. In this case, the simple practical variant implemented, do not allow the balancing.

Reminding the most basic two definitions of accuracy (partitive and holistic) we recall that the former regard the cell-by-cell accuracy, the latter the second the possibility that the updated matrix represent faithfully the real economic structure. The detail discussion of this problem can be found in (Jensen, 1980) article. In this work, the accuracy is with respectto partitive accuracy, so the considered error is equal to the distance between target matrix and estimated matrix.

Finally, in order to quantify the deviations of results between methods, among several indicators we have chosen MAE (Mean Absolute Error), MAPE (Mean Absolute Percentage Error), STPE (Standardized Total Percentage Error) and RMSE (Root Mean Square Error)[9]; STPE is the preferred measure indicator of error because of its stability.

The formulas of the chosen indicators are:

24. $$MAE = \sum_{i=1}^{n} \sum_{j=1}^{n} \left| a_{ij}^{t} - a_{ij}^{f} \right| / n$$

[9]See (Swanson, Tayman, & Bryan, 2011).

25. $MAPE = \sum_{i=1}^{n} \sum_{j=1}^{n} \left| \frac{a_{ij}^{t} - a_{ij}^{f}}{a_{ij}^{f}} \right| / n$

26. $STPE = \sum_{i=1}^{n} \sum_{j=1}^{n} \left| a_{ij}^{f} - a_{ij}^{t} \right| / \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij}^{1}$

27. $RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(a_{ij}^{t} - a_{ij}^{f} \right)^{2}}$

Where $n$represent the total number of cells and $\left| a_{ij}^{t} - a_{ij}^{f} \right|$ represents the elements of the target matrix and of forecast matrix, respectively.

2. Results

The main indicators selected to measure accuracy in projecting SAM give the following result for Standard RAS:

MAE=1266,532; **MAPE**= 15,200; **RMSE**= 15042,678; **STPE**=0,601

The following tables reports the data obtained from balancing processes by blocking each sector one by one in, respectively, row, column and "cross" configurations.

Table 5- Base results - rows blocked one by one

		Row-Type Configuration			
		MAE	MAPE	RMSE	STPE
1	LAVORO	1253,024	16,196	15032,653	0,595
2	CAPITALE	1246,885	15,505	15030,910	0,592
5	Prodotti dell'agricoltura, caccia e servizi connessi	1260,369	15,216	15003,676	0,598
7	Pesca ed altri prodotti ittici; servizi accessori della pesca	1266,181	15,191	15040,961	0,601
11	Altri prodotti delle industrie estrattive	1266,313	15,179	15041,527	0,601
17	Legno e prodotti del legno e sughero (mobili esclusi)	1265,635	15,156	15039,485	0,601
18	Carta e prodotti della carta	1264,867	14,984	15037,379	0,600
20	Coke e prodotti della raffinazione del petrolio	1260,034	15,100	15008,637	0,598
21	Prodotti chimici e fibre artificiali	1257,073	15,241	14986,640	0,597
23	Altri minerali non metalliferi	1263,761	15,157	15030,258	0,600
28	Macchine ed apparecchi elettrici	1262,820	15,444	15031,415	0,599
34	Materiale da recupero	1265,837	15,174	15041,774	0,601
35	Energia elettrica, gas e vapore	1256,567	15,300	15006,703	0,596
36	Raccolta e distribuzione dell'acqua	1265,484	15,192	15035,591	0,601
37	Costruzioni	**1199,765**	15,788	15004,781	**0,569**
38	Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	1258,292	15,131	14995,751	0,597
41	Alberghi e ristoranti	1261,092	15,317	15017,552	0,599
42	Trasporti terrestri	1246,890	15,365	**14971,050**	0,592
45	Trasporti ausiliari; agenzie di viaggio	1262,301	15,207	15031,355	0,599
47	Intermediazione finanziaria, escluso assicurazione e fondi pensione	1261,491	15,323	15020,115	0,599
49	Servizi ausiliari di intermediazione finanziaria	1264,707	**14,415**	15043,553	0,600
51	Noleggio di macchinari	1264,993	15,218	15041,134	0,600
52	Computer e servizi connessi	1263,142	15,516	15039,699	0,600
53	Ricerca e sviluppo (R&S)	1265,373	15,228	15040,497	0,601
54	Attività professionali	1240,817	15,101	15004,437	0,589
57	Sanità e servizi sociali	1256,887	15,311	14991,940	0,597
58	Smaltimento rifiuti, fognature e servizi similari	1265,799	15,190	15042,390	0,601
60	Attività ricreative, culturali e sportive	1262,943	15,241	15027,332	0,599
61	Altri servizi	1261,937	15,007	15018,451	0,599

Table 6- Base results - columns blocked one by one

		Column-Type Configuration			
		MAE	MAPE	RMSE	STPE
1	LAVORO	1266,531	15,200	15042,654	0,601
2	CAPITALE	**1237,892**	15,474	**14563,944**	**0,588**
5	Prodotti dell'agricoltura, caccia e servizi connessi	1262,485	15,124	15039,763	0,599
7	Pesca ed altri prodotti ittici; servizi accessori della pesca	1266,254	15,199	15042,601	0,601
11	Altri prodotti delle industrie estrattive	1266,104	15,209	15042,672	0,601
17	Legno e prodotti del legno e sughero (mobili esclusi)	1264,758	15,202	15041,726	0,600
18	Carta e prodotti della carta	1264,089	15,202	15040,001	0,600
20	Coke e prodotti della raffinazione del petrolio	1262,740	14,681	15041,064	0,599
21	Prodotti chimici e fibre artificiali	1254,468	15,273	15007,107	0,595
23	Altri minerali non metalliferi	1263,661	15,220	15040,613	0,600
28	Macchine ed apparecchi elettrici	1262,888	15,234	15038,876	0,599
34	Materiale da recupero	1266,313	15,190	15042,217	0,601
35	Energia elettrica, gas e vapore	1262,000	15,171	15039,337	0,599
36	Raccolta e distribuzione dell'acqua	1265,441	15,194	15042,191	0,601
37	Costruzioni	1253,374	15,166	15011,221	0,595
38	Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	1260,350	15,237	15037,683	0,598
41	Alberghi e ristoranti	1262,860	14,971	15039,346	0,599
42	Trasporti terrestri	1258,038	14,915	15031,517	0,597
45	Trasporti ausiliari; agenzie di viaggio	1261,944	15,171	15038,476	0,599
47	Intermediazione finanziaria, escluso assicurazione e fondi pensione	1264,816	15,120	15040,612	0,600
49	Servizi ausiliari di intermediazione finanziaria	1265,614	15,151	15042,287	0,601
51	Noleggio di macchinari	1265,130	15,208	15041,765	0,600
52	Computer e servizi connessi	1264,255	15,202	15040,996	0,600
53	Ricerca e sviluppo (R&S)	1266,184	**13,764**	15042,302	0,601
54	Attività professionali	1260,885	15,033	15032,413	0,598
57	Sanità e servizi sociali	1262,421	15,141	15035,728	0,599
58	Smaltimento rifiuti, fognature e servizi similari	1265,301	15,183	15042,390	0,601
60	Attività ricreative, culturali e sportive	1264,700	15,182	15042,163	0,600
61	Altri servizi	1264,469	15,178	15041,773	0,600

Respect to the table 1, blocking columns involves that the minimum errors move from the "middle internal area" of the SAM to the "high" part of the matrix. In particular, the "CAPITALE" sector, reports the best values for MAE, STPE and RMSE. The relationships between accuracy improvement provided by each sector and its specific position in the matrix area will be investigate in the follows, when we'll correlatethe multipliers value [10] of the blocked sectors and their contribution to decreasing of error indicators.

[10] The exam of the SAM multipliers matrix, both for year 2005 and year 2010, shows a concentration of the multipliers value on the diagonal and on the institutional sectors (see Appendix 1 - Multipliers).

Table 7- Base results - rows and columns simultaneously blocked one by one for each sector

		Cross-Type Configuration			
		MAE	MAPE	RMSE	STPE
1	LAVORO	1253,023	16,196	15032,650	0,595
2	CAPITALE	1218,772	15,788	**14554,111**	0,578
5	Prodotti dell'agricoltura, caccia e servizi connessi	1256,468	15,148	15000,731	0,596
7	Pesca ed altri prodotti ittici; servizi accessori della pesca	1265,904	15,190	15040,910	0,601
11	Altri prodotti delle industrie estrattive	1265,886	15,188	15041,544	0,601
17	Legno e prodotti del legno e sughero (mobili esclusi)	1264,028	15,163	15039,045	0,600
18	Carta e prodotti della carta	1262,753	15,005	15035,745	0,599
20	Coke e prodotti della raffinazione del petrolio	1256,128	14,597	15008,006	0,596
21	Prodotti chimici e fibre artificiali	1248,928	15,294	14977,153	0,593
23	Altri minerali non metalliferi	1261,083	15,179	15028,886	0,599
28	Macchine ed apparecchi elettrici	1259,470	15,470	15028,962	0,598
34	Materiale da recupero	1265,620	15,163	15041,341	0,601
35	Energia elettrica, gas e vapore	1252,639	15,278	15004,162	0,595
36	Raccolta e distribuzione dell'acqua	1264,394	15,185	15035,126	0,600
37	Costruzioni	**1193,840**	15,773	14994,279	**0,567**
38	Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	1252,449	15,157	14992,391	0,594
41	Alberghi e ristoranti	1257,569	15,099	15014,463	0,597
42	Trasporti terrestri	1242,183	15,116	14962,313	0,590
45	Trasporti ausiliari; agenzie di viaggio	1257,848	15,179	15027,183	0,597
47	Intermediazione finanziaria, escluso assicurazione e fondi pensione	1259,833	15,244	15018,088	0,598
49	Servizi ausiliari di intermediazione finanziaria	1264,104	14,411	15043,104	0,600
51	Noleggio di macchinari	1263,643	15,226	15040,272	0,600
52	Computer e servizi connessi	1261,255	15,506	15038,448	0,599
53	Ricerca e sviluppo (R&S)	1265,074	**13,845**	15040,248	0,600
54	Attività professionali	1236,581	14,959	14999,470	0,587
57	Sanità e servizi sociali	1253,836	15,235	14987,560	0,595
58	Smaltimento rifiuti, fognature e servizi similari	1264,667	15,171	15042,169	0,600
60	Attività ricreative, culturali e sportive	1261,620	15,227	15026,578	0,599
61	Altri servizi	1260,053	14,992	15017,096	0,598

The distribution of the errors in matrix areas is analyzed in detail in the **Appendix 1 – Distribution of the errors** and suggests a prevalence of the "High" and "Middle" areas respect to the "Low" area about the effects of the constraints application in terms of decreasing of the errors measured by MAE, MAPE, RMSE and STPE.

It's now interesting compare the multipliers values to the error performance for each sector in the different type of constraints configuration. Before of this, its useful report the performance of each sector in terms of change of the selected indicators, in all the three constraints configuration schemes, respect to the Standard RAS method.

Figure 4–Contribution of each blocked sector to percentage decreasing of selected indicators - %

	Row-Type				Column-Type				Cross-Type			
	MAE	MAPE	RMSE	STPE	MAE	MAPE	RMSE	STPE	MAE	MAPE	RMSE	STPE
1	-1,07%	6,55%	-0,07%	-1,07%	0,00%	0,00%	0,00%	0,00%	-1,07%	6,55%	-0,07%	-1,07%
2	-1,55%	2,01%	-0,08%	-1,55%	**-2,26%**	1,80%	**-3,18%**	**-2,26%**	-3,77%	3,87%	-3,25%	-3,77%
5	-0,49%	0,11%	-0,26%	-0,49%	-0,32%	-0,50%	-0,02%	-0,32%	-0,79%	-0,35%	-0,28%	-0,79%
7	-0,03%	-0,06%	-0,01%	-0,03%	-0,02%	-0,01%	0,00%	-0,02%	-0,05%	-0,07%	-0,01%	-0,05%
11	-0,02%	-0,14%	-0,01%	-0,02%	-0,03%	0,06%	0,00%	-0,03%	-0,05%	-0,08%	-0,01%	-0,05%
17	-0,07%	-0,29%	-0,02%	-0,07%	-0,14%	0,01%	-0,01%	-0,14%	-0,20%	-0,24%	-0,02%	-0,20%
18	-0,13%	-1,42%	-0,04%	-0,13%	-0,19%	0,01%	-0,02%	-0,19%	-0,30%	-1,29%	-0,05%	-0,30%
20	-0,51%	-0,66%	-0,23%	-0,51%	-0,30%	-3,42%	-0,01%	-0,30%	-0,82%	-3,97%	-0,23%	-0,82%
21	-0,75%	0,27%	-0,37%	-0,75%	-0,95%	0,48%	-0,24%	-0,95%	-1,39%	0,61%	-0,44%	-1,39%
23	-0,22%	-0,28%	-0,08%	-0,22%	-0,23%	0,13%	-0,01%	-0,23%	-0,43%	-0,14%	-0,09%	-0,43%
28	-0,29%	1,60%	-0,07%	-0,29%	-0,29%	0,22%	-0,03%	-0,29%	-0,56%	1,77%	-0,09%	-0,56%
34	-0,05%	-0,18%	-0,01%	-0,05%	-0,02%	-0,07%	0,00%	-0,02%	-0,07%	-0,25%	-0,01%	-0,07%
35	-0,79%	0,66%	-0,24%	-0,79%	-0,36%	-0,19%	-0,02%	-0,36%	-1,10%	0,51%	-0,26%	-1,10%
36	-0,08%	-0,06%	-0,05%	-0,08%	-0,09%	-0,04%	0,00%	-0,09%	-0,17%	-0,10%	-0,05%	-0,17%
37	**-5,27%**	3,87%	-0,25%	**-5,27%**	-1,04%	-0,23%	-0,21%	-1,04%	**-5,74%**	3,77%	-0,32%	**-5,74%**
38	-0,65%	-0,46%	-0,31%	-0,65%	-0,49%	0,24%	-0,03%	-0,49%	-1,11%	-0,28%	-0,33%	-1,11%
41	-0,43%	0,77%	-0,17%	-0,43%	-0,29%	-1,51%	-0,02%	-0,29%	-0,71%	-0,67%	-0,19%	-0,71%
42	-1,55%	1,08%	**-0,48%**	-1,55%	-0,67%	-1,88%	-0,07%	-0,67%	-1,92%	-0,55%	**-0,53%**	-1,92%
45	-0,33%	0,05%	-0,08%	-0,33%	-0,36%	-0,19%	-0,03%	-0,36%	-0,69%	-0,14%	-0,10%	-0,69%
47	-0,40%	0,81%	-0,15%	-0,40%	-0,14%	-0,53%	-0,01%	-0,14%	-0,53%	0,29%	-0,16%	-0,53%
49	-0,14%	**-5,17%**	**0,01%**	-0,14%	-0,07%	-0,32%	0,00%	-0,07%	-0,19%	**-5,19%**	0,00%	-0,19%
51	-0,12%	0,12%	-0,01%	-0,12%	-0,11%	0,05%	-0,01%	-0,11%	-0,23%	0,17%	-0,02%	-0,23%
52	-0,27%	2,08%	-0,02%	-0,27%	-0,18%	0,01%	-0,01%	-0,18%	-0,42%	2,01%	-0,03%	-0,42%
53	-0,09%	0,18%	-0,01%	-0,09%	-0,03%	**-9,45%**	0,00%	-0,03%	-0,12%	-8,92%	-0,02%	-0,12%
54	-2,03%	-0,66%	-0,25%	-2,03%	-0,45%	-1,10%	-0,07%	-0,45%	-2,36%	-1,59%	-0,29%	-2,36%
57	-0,76%	0,73%	-0,34%	-0,76%	-0,32%	-0,39%	-0,05%	-0,32%	-1,00%	0,23%	-0,37%	-1,00%
58	-0,06%	-0,07%	0,00%	-0,06%	-0,10%	-0,11%	0,00%	-0,10%	-0,15%	-0,20%	0,00%	-0,15%
60	-0,28%	0,27%	-0,10%	-0,28%	-0,14%	-0,12%	0,00%	-0,14%	-0,39%	0,17%	-0,11%	-0,39%
61	-0,36%	-1,27%	-0,16%	-0,36%	-0,16%	-0,15%	-0,01%	-0,16%	-0,51%	-1,37%	-0,17%	-0,51%
Sum	**-18,80%**	**10,42%**	**-3,86%**	**-18,80%**	**-9,75%**	**-17,20%**	**-4,07%**	**-9,75%**	**-26,83%**	**-5,43%**	**-7,48%**	**-26,83%**
Mean	**-0,65%**	**0,36%**	**-0,13%**	**-0,65%**	**-0,34%**	**-0,59%**	**-0,14%**	**-0,34%**	**-0,93%**	**-0,19%**	**-0,26%**	**-0,93%**

Where the numbers of sectors follow the below scheme:

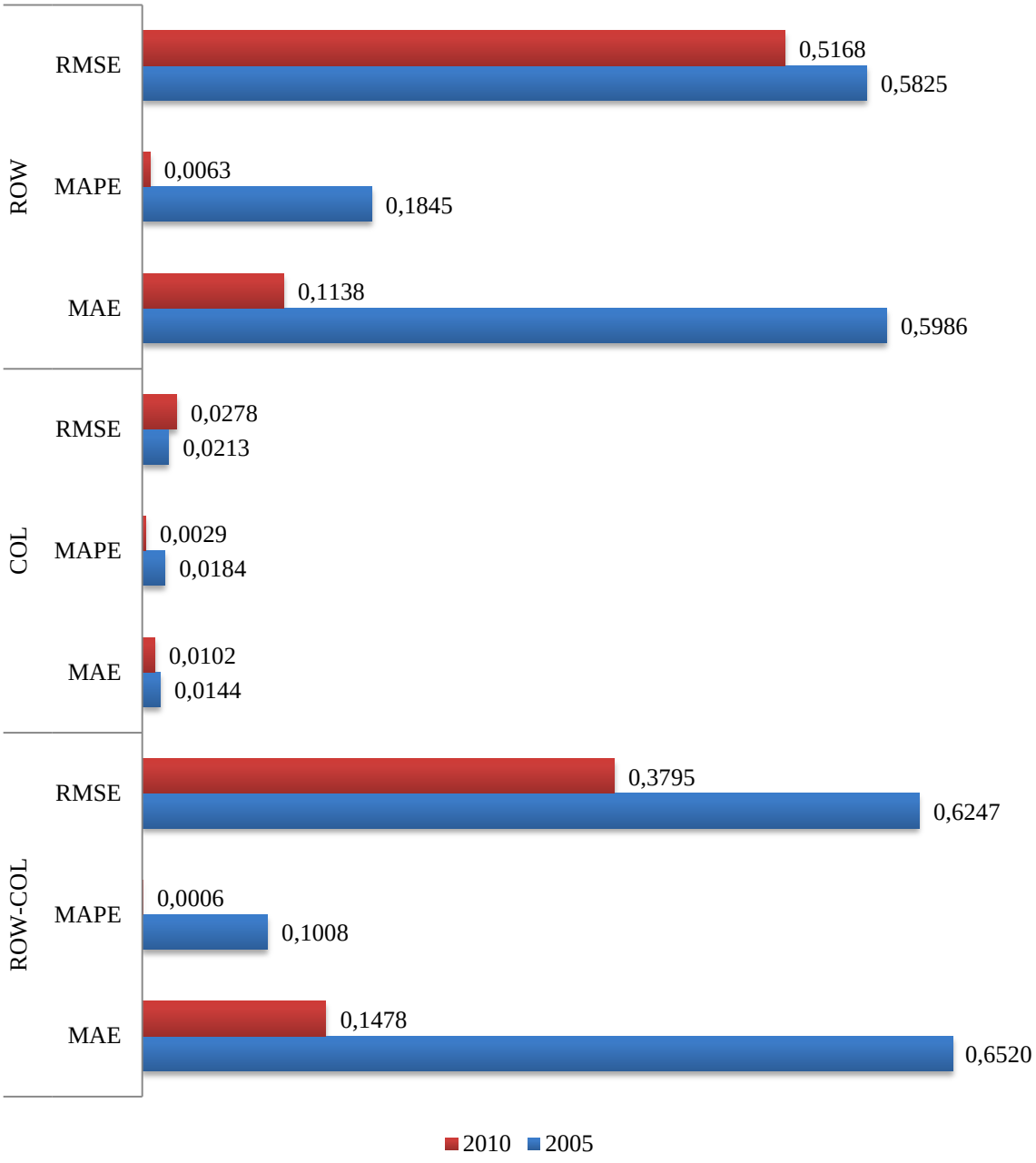
1 LAVORO
2 CAPITALE
5 Prodotti dell'agricoltura, caccia e servizi connessi
7 Pesca ed altri prodotti ittici; servizi accessori della pesca
11 Altri prodotti delle industrie estrattive
17 Legno e prodotti del legno e sughero (mobili esclusi)
18 Carta e prodotti della carta
20 Coke e prodotti della raffinazione del petrolio
21 Prodotti chimici e fibre artificiali
23 Altri minerali non metalliferi
28 Macchine ed apparecchi elettrici
34 Materiale da recupero
35 Energia elettrica, gas e vapore
36 Raccolta e distribuzione dell'acqua
37 Costruzioni
38 Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.
41 Alberghi e ristoranti
42 Trasporti terrestri
45 Trasporti ausiliari; agenzie di viaggio
47 Intermediazione finanziaria, escluso assicurazione e fondi pensione
49 Servizi ausiliari di intermediazione finanziaria
51 Noleggio di macchinari
52 Computer e servizi connessi
53 Ricerca e sviluppo (R&S)
54 Attività professionali
57 Sanità e servizi sociali
58 Smaltimento rifiuti, fognature e servizi similari
60 Attività ricreative, culturali e sportive
61 Altri servizi

Figure X shows clearly that blocking a sector in balancing process adds accuracy in projecting SAM. In particular, you can see that for the sectors considered one by one, the average gain in forecasting precision is around the 1% for MAE and STPE, with considerable variations between sectors: see, for MAE in row-type configuration,sector 7 (0.07%) compared to sector 37(-5.27 %).

The complete comparison of the twelve measures of performance of the figure X to the six aggregations of the multipliers (row, column, row-column for the years, 2005 and 2010) is reported in the Appendix 1 – Comparison among multipliers and contribution to error decrease. The comparison is performed, for year 2005 and 2010, correlating each scheme with the decrease of MAE, MAPE, RMSE and STPE coming from corresponding constraints configuration (so, the sum of the multipliers values by row is correlated with the decrease of indicators coming from row constraints scheme).

The figure X shows the comparison among the determination coefficient (R^2) calculated in the test session reported in the Appendix 1 at the abovementioned section.
The Pearson test indicates that the row-column multipliers sum correlated with the decrease of error indicators coming from row-column configuration constraints show the strong correlation.

Figure 5–R^2 calculated correlating multipliers values for row, column, row-column with the decrease of MAE[11], MAPE, RMSE from balancing, for the three constraints configurations



Naturally, the results reported in the above figure are not sufficient to postulate functional relationships between multipliers values and capacity of related sectors, if blocked in RAS balancing, to resolve in accuracy gain when projecting matrix. However, the test performed, seems to indicate an interest about further investigation about this point.

[11] The STPE results, in terms of percentage decrease of error to Standard RAS, are equal to MAE and, therefore, omitted.

Combined constraints

It seems reasonable, on the basis of what previously established, investigate on the effects produced when the sectors are simultaneously blocked in a cumulative balancing iteration. The test was performed only for MAE, to get a first order assessment of the effects.

Table 8- Accuracy gain in forecasting SAM 2010 by blocking a cumulative set of sectors

	MAE decrease	Sum of single contribution to MAE decrease
2+37	-9,27%	-9,51%
2+37+54	-11,12%	-11,88%
2+37+42+54	-12,92%	-13,80%
2+21+37+42+54	-14,26%	-15,19%
2+21+37+38+42+54	-15,26%	-16,30%
2+21+35+37+38+42+54	-16,24%	-17,40%
2+21+35+37+38+42+54+57	-17,29%	-18,12%
2+20+21+35+37+38+42+54+57	-17,81%	-19,22%
2+6+20+21+35+37+38+42+54+57	-18,54%	-20,02%
2+6+20+21+35+37+38+42+45+54+57	-19,20%	-20,72%

The above table, shows what happens when we block, one by one, the sectors, adding every new sector to the initial ones. So, adding the sector 54 to the 2+37 produces a further decrease of MAE by 1,85% and so on.

Figure 6 - MAE decreasing from combined cross constraints application compared to sum of single MAE decreasing from blocking each sector one by one

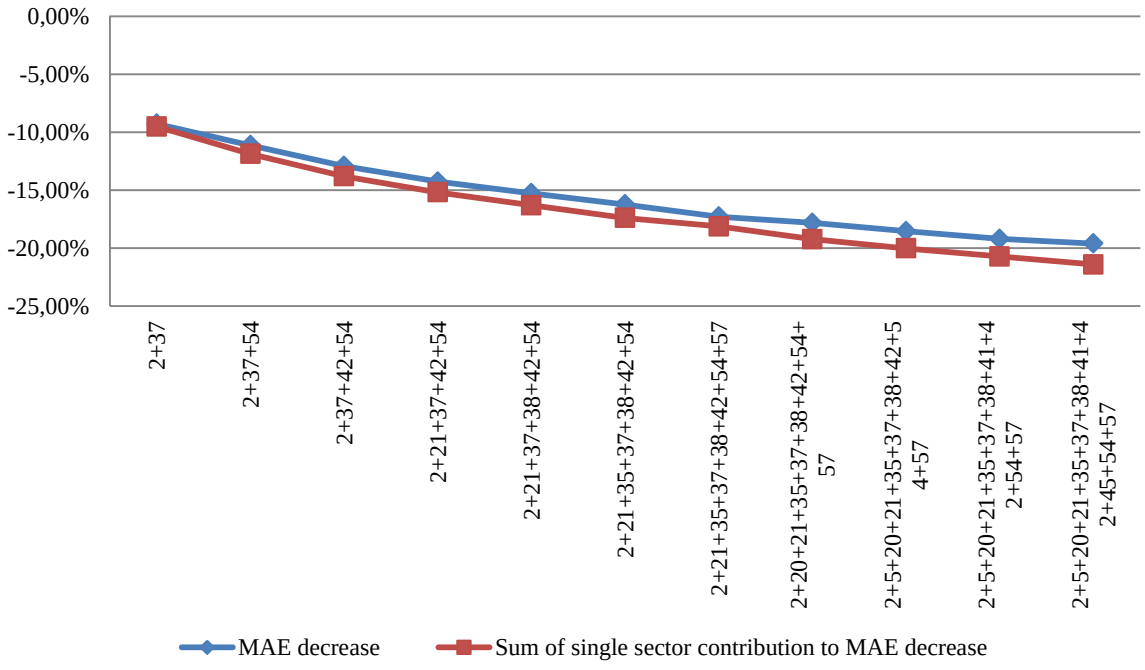


Figure 6 shows the explicative capacity of combined constraints application with respect to single contribute of each sector expressed as the difference between respective trends. So, it can be noted that introducing a new sector (57) modified the decreasing trends (that suggest a greater effect of the combined constraints to the sum of single contribute), probably due to the multipliers effects in the balancing process[12].

Figure 7 - Percentage difference between MAE estimated by RAS blocking several sector simultaneously

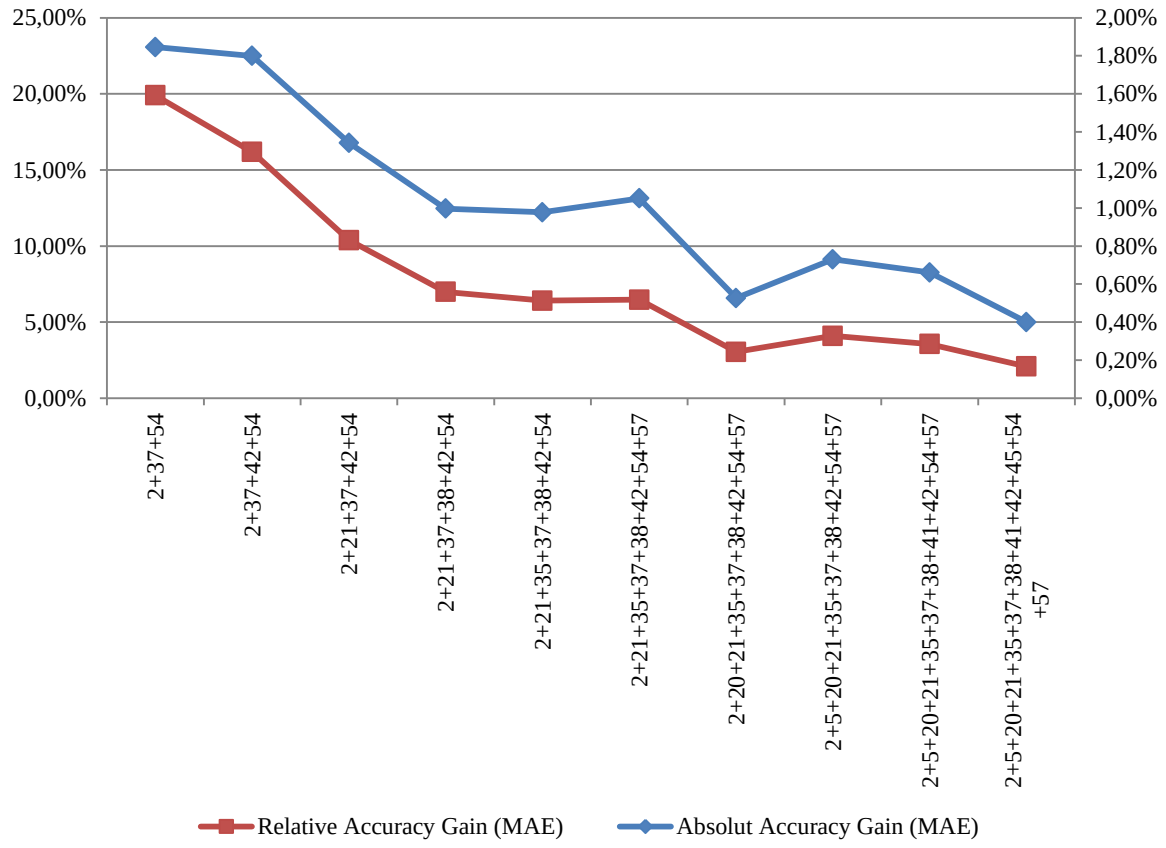


Figure 7 shows the cumulated decrease of MAE when new sectors are blocked together with the initial one. So, moving from sector 2+37+54 (blocked) to 2+37+42+54, we get a decrease of MAE of 1,80 % in absolute terms where the relative measure decreases by of 3,73% (this means that the ratio between the relateddecrease of MAE moves from 19,91% to 16,18%).

[12]This type of effects indicate the possibilities of investigate on the relationships between disaggregation grade for matrix and intensity of the effects by application of the constraints, especially in the case of disaggregation focused to specific sector analysis (RAO, CIORBA, TROVATO, NOTARO, & FERRARESE, 2014).

Conclusion

Searching for a better estimate of a matrix based on the structure of a previous oneand margins of another matrix is a very general problem that contain elements of interest for many applications in several research areas (Norman, 1999), (Lahr & De Mesnard, 2004).
Bi-proportional methods are efficient where information is missing, unavailable, and when econometric estimation is at least difficult if not impossible—typically where phenomena are represented by matrices.
The iterative methods proposed in this work can be applied in many fields outside the developing application to National Accounting.

This report presents a variant application, a simple algorithm developed in VBA that measure the accuracy gain in projecting a SAM through the application of different configurations of "cross-type" constraints.

The results suggest that investigatingthe information gain from constraints use is a usefulanalysis that could be improved by comparing the "cross-type" constraints, with different typology set (radial, angular, concentrated in specific areas of the matrix).

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Appendix 1 - The Social Accounting Matrix for Italy for years 2005 and 2010

General notes

The flows, expressed in currency, reported in the tablesfor years 2005 and 2010represents the following economic activity sectors:
According to the before mentioned classification, the 1 to 4 and 63 to 65 sectors correspond to institutional sectors, the remaining to productive sectors.

1	LAVORO
2	CAPITALE
3	FAMIGLIE
4	IMPRESE
5	Prodotti dell'agricoltura, caccia e servizi connessi
6	Prodotti della silvicoltura e servizi connessi
7	Pesca ed altri prodotti ittici; servizi accessori della pesca
8	Carbon fossile
9	Petrolio e gas naturale; servizi accessori all'estrazione di olio e gas
10	Estrazione di minerali metalliferi
11	Altri prodotti delle industrie estrattive
12	Prodotti alimentari e bevande
13	Industria del tabacco
14	Prodotti tessili
15	Vestiario e pellicce
16	Cuoio e prodotti in pelle
17	Legno e prodotti del legno e sughero (mobili esclusi)
18	Carta e prodotti della carta
19	Editoria e stampa
20	Coke e prodotti della raffinazione del petrolio
21	Prodotti chimici e fibre artificiali
22	Gomma e prodotti in plastica
23	Altri minerali non metalliferi
24	Metalli e leghe
25	Prodotti metallici, eccetto macchine ed apparecchi
26	Macchine ed apparecchi meccanici
27	Macchine per ufficio e computer
28	Macchine ed apparecchi elettrici
29	Apparecchi radiotelevisivi
30	Apparecchi medicali, di precisione, strumenti ottici ed orologi
31	Veicoli a motore e rimorchi
32	Altri mezzi di trasporto
33	Mobili ed altri prodotti manifatturieri
34	Materiale da recupero
35	Energia elettrica, gas e vapore

36	Raccolta e distribuzione dell'acqua
37	Costruzioni
38	Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.
39	Commercio all'ingrosso, esclusi veicoli a motore e motocicli
40	Commercio al dettaglio, esclusi veicoli a motore e motocicli
41	Alberghi e ristoranti
42	Trasporti terrestri
43	Trasporti marittimi
44	Trasporti aerei
45	Trasporti ausiliari; agenzie di viaggio
46	Poste e telecomunicazioni
47	Intermediazione finanziaria, escluso assicurazione e fondi pensione
48	Assicurazione e fondi pensione, esclusa previdenza sociale obbligatoria
49	Servizi ausiliari di intermediazione finanziaria
50	Attività immobiliari
51	Noleggio di macchinari
52	Computer e servizi connessi
53	Ricerca e sviluppo (R&S)
54	Attività professionali
55	Pubblica amministrazione e difesa; previdenza sociale obbligatoria
56	Istruzione
57	Sanità e servizi sociali
58	Smaltimento rifiuti, fognature e servizi similari
59	Organizzazioni associative
60	Attività ricreative, culturali e sportive
61	Altri servizi
62	Servizi domestici
63	GOVERNO
64	FORMAZIONE DI CAPITALE
65	RESTO DEL MONDO

The used nomenclature has been setting by the researchers of the University of Rome "Tor Vergata" and follows the ATECO(Istat, 2009)nomenclature used by Istat[13].In the next page, an aggregation of the above sectors is presented to report the SAM at year 2005 and the SAM at year 2010. The reported aggregation follow the below scheme:

LABOUR	LAVORO
CAPITAL	CAPITALE
HOUSEHOLDS	FAMIGLIE
FIRMS	IMPRESE
Production sectors	Sectors from 5 to 62
GOVERNMENT	GOVERNO
FIXED CAPITAL FORMATION	FORMAZIONE DI CAPITALE
REST OF THE WORLD	RESTO DEL MONDO

[13] The nomenclature is reported in Italian language to avoid some possible misunderstanding in translation from ATECO Nomenclature to aggregation operated by Tor Vergata.

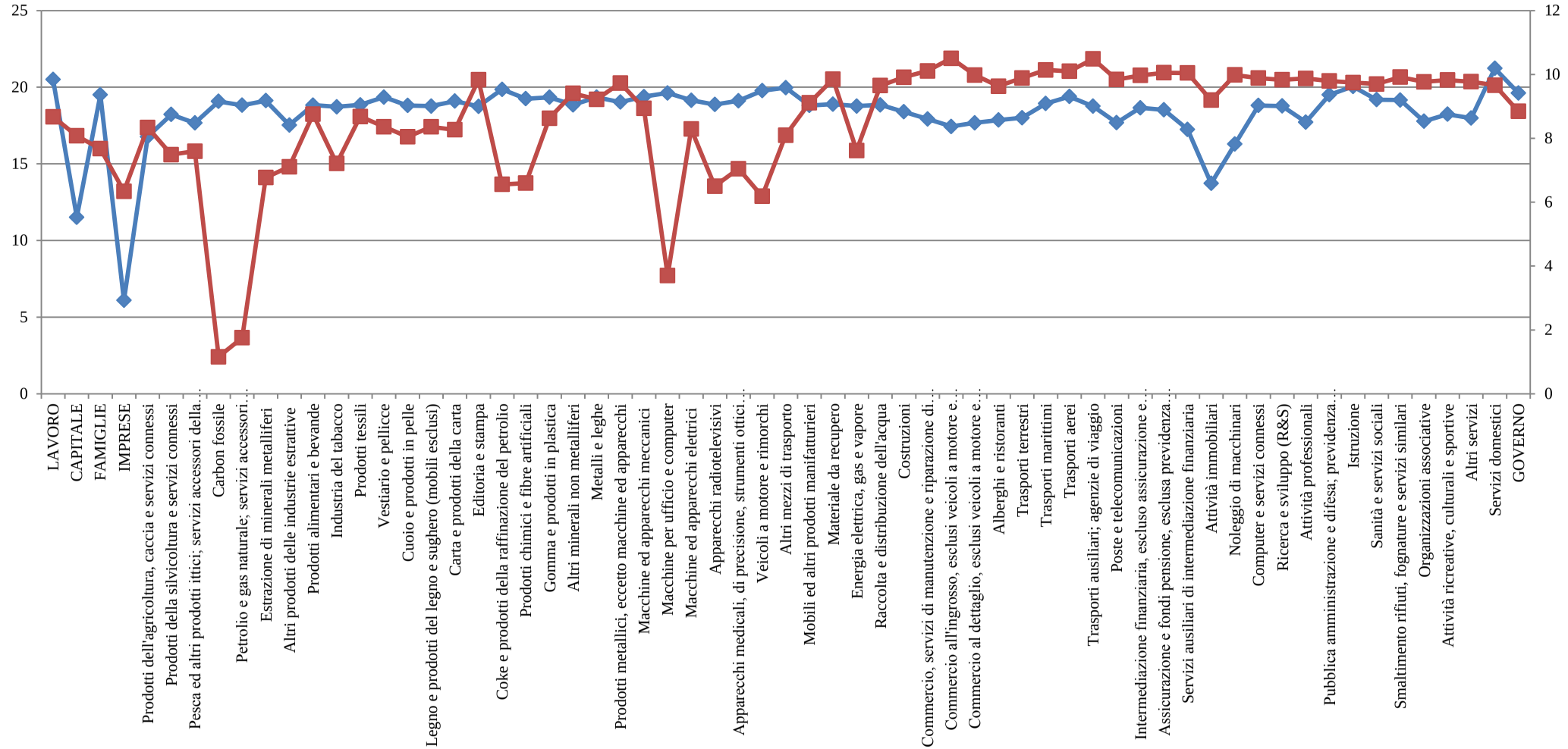
SAM 2005	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	581,32	0,00	0,00	0,00	581,317
CAPITAL	0,00	0,00	0,00	0,00	654,30	0,00	0,00	0,00	654,298
HOUSEHOLDS	581,32	204,00	175,39	64,98	0,00	259,35	0,00	10,19	1295,220
FIRMS	0,00	438,84	0,00	0,00	0,00	11,34	0,00	0,00	450,179
Production sectors	0,00	0,00	744,50	2,08	1363,38	278,08	288,63	282,90	2959,572
GOVERNMENT	0,00	11,46	255,06	50,06	193,05	17,93	39,14	0,00	566,703
FIXED CAPITAL FORMATION	0,00	0,00	0,00	333,06	0,00	0,00	0,00	18,03	351,094
REST OF THE WORLD	0,00	0,00	120,27	0,00	167,53	0,00	23,32	0,00	311,122
TOTAL	581,317	654,298	1295,220	450,179	2959,572	566,703	351,094	311,122	

SAM 2010	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	617,41	0,00	0,00	0,00	617,411
CAPITAL	0,00	0,00	0,00	0,00	725,80	0,00	0,00	0,00	725,802
HOUSEHOLDS	617,41	399,63	273,82	331,28	0,00	291,06	0,00	36,49	1949,687
FIRMS	0,00	326,17	0,00	0,00	0,00	30,86	0,00	252,79	609,822
Production sectors	0,00	0,00	1007,26	20,91	1479,25	60,39	289,39	314,13	3171,329
GOVERNMENT	0,00	0,00	159,34	57,44	122,95	0,00	44,60	0,00	384,336
FIXED CAPITAL FORMATION	0,00	0,00	415,90	200,19	0,00	2,03	0,00	110,94	729,055
REST OF THE WORLD	0,00	0,00	93,37	0,00	225,91	0,00	395,06	0,00	714,348
TOTAL	617,411	725,802	1949,687	609,822	3171,329	384,336	729,055	714,348	

The Multipliers

The following graphs shows the values of the multipliers calculated by rows, columns and as a sum of rows and columns.

Figure 1 - Multipliers of 2005 SAM - sum by columns



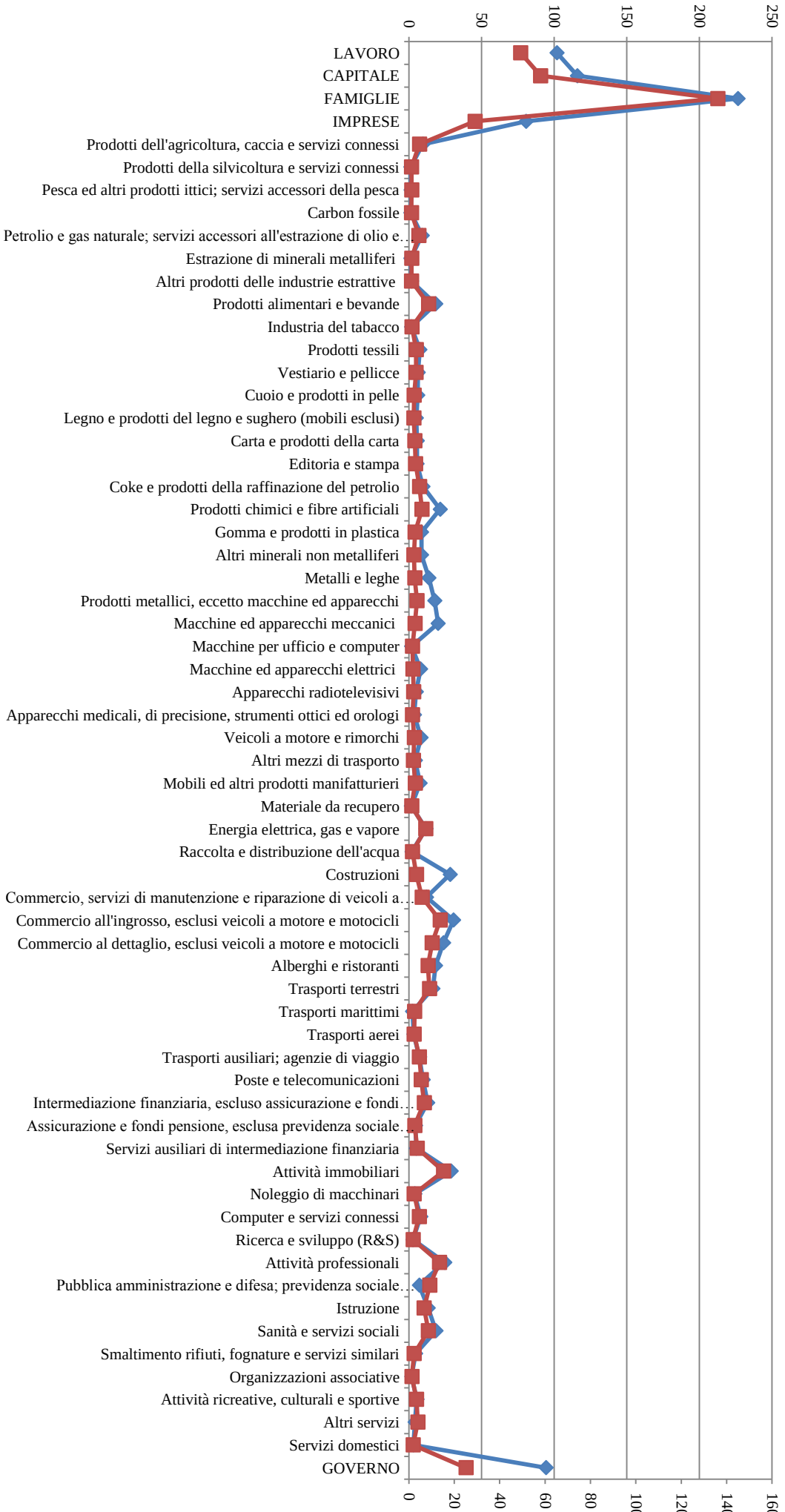


Figure 2 - Multipliers of 2005 SAM - sum by rows

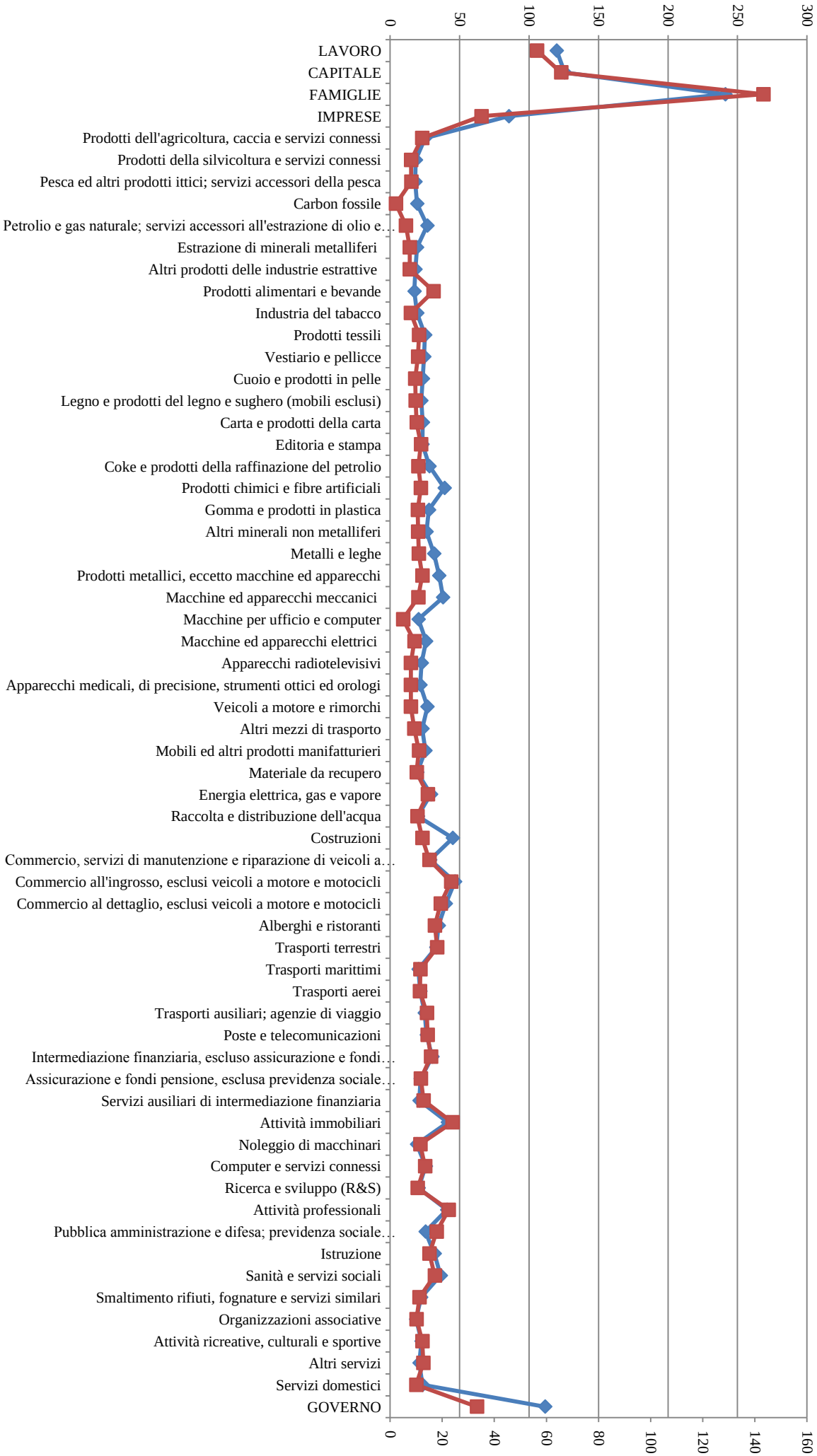


Figure 3 - Multipliers of 2005 SAM - sum by rows columns

The Table 4 reports the sum by row, by column and by rows + column for Italian SAM in year 2005 and 2010:

Table 1 - Distribution of multipliers value by SAM areas (high, mid, low)

	2005				2010			
Sectors Areas	by row	by column	intersection rows-columns	by rows + column	by row	by column	intersection rows-columns	by rows + column
Multipliers from 1 to 21	638,25	375,16	220,89	792,52	324,00	151,66	105,41	370,26
Multipliers from 22 to 42	252,89	395,09	108,06	539,92	88,54	182,02	49,28	221,28
Multipliers from 43 to 63	266,41	387,29	100,79	552,91	127,60	206,45	61,50	272,55
Totals	**1157,54**	**1157,54**	**429,73**	**1885,35**	**540,14**	**540,14**	**216,19**	**864,09**
Total Matrix				**1157,54**				**540,14**

The sum of the Multipliers calculated by row and by column involves more than a double counting, as shown below:

		2	2	6	7	**17**
		4	5	5	5	**19**
Total Area	**69**	3	4	4	8	**19**
		9	2	2	1	**14**
		18	**13**	**17**	**21**	
Area 1 by row	36	2	2	6	7	**17**
Area 1 by column	31	4	5	5	5	**19**
Intersection	13	3	4	4	8	**19**
Area 1 by row + by column	**54**	9	2	2	1	**14**
		18	**13**	**17**	**21**	
Area 2 by row	33	2	2	6	7	**17**
Area 2 by column	38	4	5	5	5	**19**
Intersection	15	3	4	4	8	**19**
Area 2 by row + by column	**56**	9	2	2	1	**14**
		18	**13**	**17**	**21**	
Area 1- 2 by row + by column	**110**					
		2	2	6	7	**17**
		4	5	5	5	**19**
(Area 1- 2) - Total Area	**41**	3	4	4	8	**19**
		9	2	2	1	**14**
		18	**13**	**17**	**21**	

So, the fourth column of Table 4, do not match with the total of the multipliers. This kind of calculation is performed to take into account the single multiplier's areas, one by one (low, middle, high) in order to compare the multipliers values with the performance of the economic sector in terms of projection accuracy (especially when constraints on sectors were cumulated).

Distribution of the errors in the matrix areas

A graphical inspection of the error tables for the used indicators shows the following results, expressed in color scale to give an immediate view of error distribution among sectors (the green values are the minimum errors).The letters H,M,L in the first column represents the “high” (sectors from 1 to 22), “middle” (sectors from 23 to 43), “low”(sectors from 44 to 63[14]) part of the matrix.

Table 2 - Distribution of errors for the used indicators in blocked sectors - Row-Type configuration

		Row-Type Configuration			
		MAE	MAPE	RMSE	STPE
H	LAVORO	1253,024	16,196	15032,653	0,595
H	CAPITALE	1246,885	15,505	15030,910	0,592
H	Prodotti dell'agricoltura, caccia e servizi connessi	1260,369	15,216	15003,676	0,598
H	Pesca ed altri prodotti ittici; servizi accessori della pesca	1266,181	15,191	15040,961	0,601
H	Altri prodotti delle industrie estrattive	1266,313	15,179	15041,527	0,601
H	Legno e prodotti del legno e sughero (mobili esclusi)	1265,635	15,156	15039,485	0,601
H	Carta e prodotti della carta	1264,867	14,984	15037,379	0,600
H	Coke e prodotti della raffinazione del petrolio	1260,034	15,100	15008,637	0,598
H	Prodotti chimici e fibre artificiali	1257,073	15,241	14986,640	0,597
M	Altri minerali non metalliferi	1263,761	15,157	15030,258	0,600
M	Macchine ed apparecchi elettrici	1262,820	15,444	15031,415	0,599
M	Materiale da recupero	1265,837	15,174	15041,774	0,601
M	Energia elettrica, gas e vapore	1256,567	15,300	15006,703	0,596
M	Raccolta e distribuzione dell'acqua	1265,484	15,192	15035,591	0,601
M	Costruzioni	**1199,765**	15,788	15004,781	**0,569**
M	Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	1258,292	15,131	14995,751	0,597
M	Alberghi e ristoranti	1261,092	15,317	15017,552	0,599
M	Trasporti terrestri	1246,890	15,365	**14971,050**	0,592
L	Trasporti ausiliari; agenzie di viaggio	1262,301	15,207	15031,355	0,599
L	Intermediazione finanziaria, escluso assicurazione e fondi pensione	1261,491	15,323	15020,115	0,599
L	Servizi ausiliari di intermediazione finanziaria	1264,707	**14,415**	15043,553	0,600
L	Noleggio di macchinari	1264,993	15,218	15041,134	0,600
L	Computer e servizi connessi	1263,142	15,516	15039,699	0,600
L	Ricerca e sviluppo (R&S)	1265,373	15,228	15040,497	0,601
L	Attività professionali	1240,817	15,101	15004,437	0,589
L	Sanità e servizi sociali	1256,887	15,311	14991,940	0,597
L	Smaltimento rifiuti, fognature e servizi similari	1265,799	15,190	15042,390	0,601
L	Attività ricreative, culturali e sportive	1262,943	15,241	15027,332	0,599
L	Altri servizi	1261,937	15,007	15018,451	0,599

[14] We consider 63 sectors, in order to investigate on the multipliers calculated by truncating the “exogenous sector” (in this case, FORMAZIONE DI CAPITALE e RESTO DEL MONDO).

Table 3 - Distribution of errors for the used indicators in blocked sectors - Row-Type configuration

		Column-Type configuration			
		MAE	MAPE	RMSE	STPE
H	LAVORO	1266,531	15,200	15042,654	0,601
H	CAPITALE	1237,892	15,474	14563,944	0,588
H	Prodotti dell'agricoltura, caccia e servizi connessi	1262,485	15,124	15039,763	0,599
H	Pesca ed altri prodotti ittici; servizi accessori della pesca	1266,254	15,199	15042,601	0,601
H	Altri prodotti delle industrie estrattive	1266,104	15,209	15042,672	0,601
H	Legno e prodotti del legno e sughero (mobili esclusi)	1264,758	15,202	15041,726	0,600
H	Carta e prodotti della carta	1264,089	15,202	15040,001	0,600
H	Coke e prodotti della raffinazione del petrolio	1262,740	14,681	15041,064	0,599
H	Prodotti chimici e fibre artificiali	1254,468	15,273	15007,107	0,595
M	Altri minerali non metalliferi	1263,661	15,220	15040,613	0,600
M	Macchine ed apparecchi elettrici	1262,888	15,234	15038,876	0,599
M	Materiale da recupero	1266,313	15,190	15042,217	0,601
M	Energia elettrica, gas e vapore	1262,000	15,171	15039,337	0,599
M	Raccolta e distribuzione dell'acqua	1265,441	15,194	15042,191	0,601
M	Costruzioni	**1253,374**	15,166	15011,221	**0,595**
M	Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	1260,350	15,237	15037,683	0,598
M	Alberghi e ristoranti	1262,860	14,971	15039,346	0,599
M	Trasporti terrestri	1258,038	14,915	**15031,517**	0,597
L	Trasporti ausiliari; agenzie di viaggio	1261,944	15,171	15038,476	0,599
L	Intermediazione finanziaria, escluso assicurazione e fondi pensione	1264,816	15,120	15040,612	0,600
L	Servizi ausiliari di intermediazione finanziaria	1265,614	**15,151**	15042,287	0,601
L	Noleggio di macchinari	1265,130	15,208	15041,765	0,600
L	Computer e servizi connessi	1264,255	15,202	15040,996	0,600
L	Ricerca e sviluppo (R&S)	1266,184	13,764	15042,302	0,601
L	Attività professionali	1260,885	15,033	15032,413	0,598
L	Sanità e servizi sociali	1262,421	15,141	15035,728	0,599
L	Smaltimento rifiuti, fognature e servizi similari	1265,301	15,183	15042,390	0,601
L	Attività ricreative, culturali e sportive	1264,700	15,182	15042,163	0,600
L	Altri servizi	1264,469	15,178	15041,773	0,600

Table 4 - Distribution of errors for the used indicators in blocked sectors - Row-Type configuration

		Cross-Type configuration			
		MAE	MAPE	RMSE	STPE
H	LAVORO	1253,023	16,196	15032,650	0,595
H	CAPITALE	1218,772	15,788	14554,111	0,578
H	Prodotti dell'agricoltura, caccia e servizi connessi	1256,468	15,148	15000,731	0,596
H	Pesca ed altri prodotti ittici; servizi accessori della pesca	1265,904	15,190	15040,910	0,601
H	Altri prodotti delle industrie estrattive	1265,886	15,188	15041,544	0,601
H	Legno e prodotti del legno e sughero (mobili esclusi)	1264,028	15,163	15039,045	0,600
H	Carta e prodotti della carta	1262,753	15,005	15035,745	0,599
H	Coke e prodotti della raffinazione del petrolio	1256,128	14,597	15008,006	0,596
H	Prodotti chimici e fibre artificiali	1248,928	15,294	14977,153	0,593
M	Altri minerali non metalliferi	1261,083	15,179	15028,886	0,599

M	Macchine ed apparecchi elettrici	1259,470	15,470	15028,962	0,598
M	Materiale da recupero	1265,620	15,163	15041,341	0,601
M	Energia elettrica, gas e vapore	1252,639	15,278	15004,162	0,595
M	Raccolta e distribuzione dell'acqua	1264,394	15,185	15035,126	0,600
M	Costruzioni	**1193,840**	15,773	14994,279	**0,567**
M	Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	1252,449	15,157	14992,391	0,594
M	Alberghi e ristoranti	1257,569	15,099	15014,463	0,597
M	Trasporti terrestri	1242,183	15,116	**14962,313**	0,590
L	Trasporti ausiliari; agenzie di viaggio	1257,848	15,179	15027,183	0,597
L	Intermediazione finanziaria, escluso assicurazione e fondi pensione	1259,833	15,244	15018,088	0,598
L	Servizi ausiliari di intermediazione finanziaria	1264,104	**14,411**	15043,104	0,600
L	Noleggio di macchinari	1263,643	15,226	15040,272	0,600
L	Computer e servizi connessi	1261,255	15,506	15038,448	0,599
L	Ricerca e sviluppo (R&S)	1265,074	13,845	15040,248	0,600
L	Attività professionali	1236,581	14,959	14999,470	0,587
L	Sanità e servizi sociali	1253,836	15,235	14987,560	0,595
L	Smaltimento rifiuti, fognature e servizi similari	1264,667	15,171	15042,169	0,600
L	Attività ricreative, culturali e sportive	1261,620	15,227	15026,578	0,599
L	Altri servizi	1260,053	14,992	15017,096	0,598

Some basic statistics on Table 5-6-7 give the following results:

Figure 4 - Cumulated errors for the used indicators by matrix areas (High, Mid, Low)

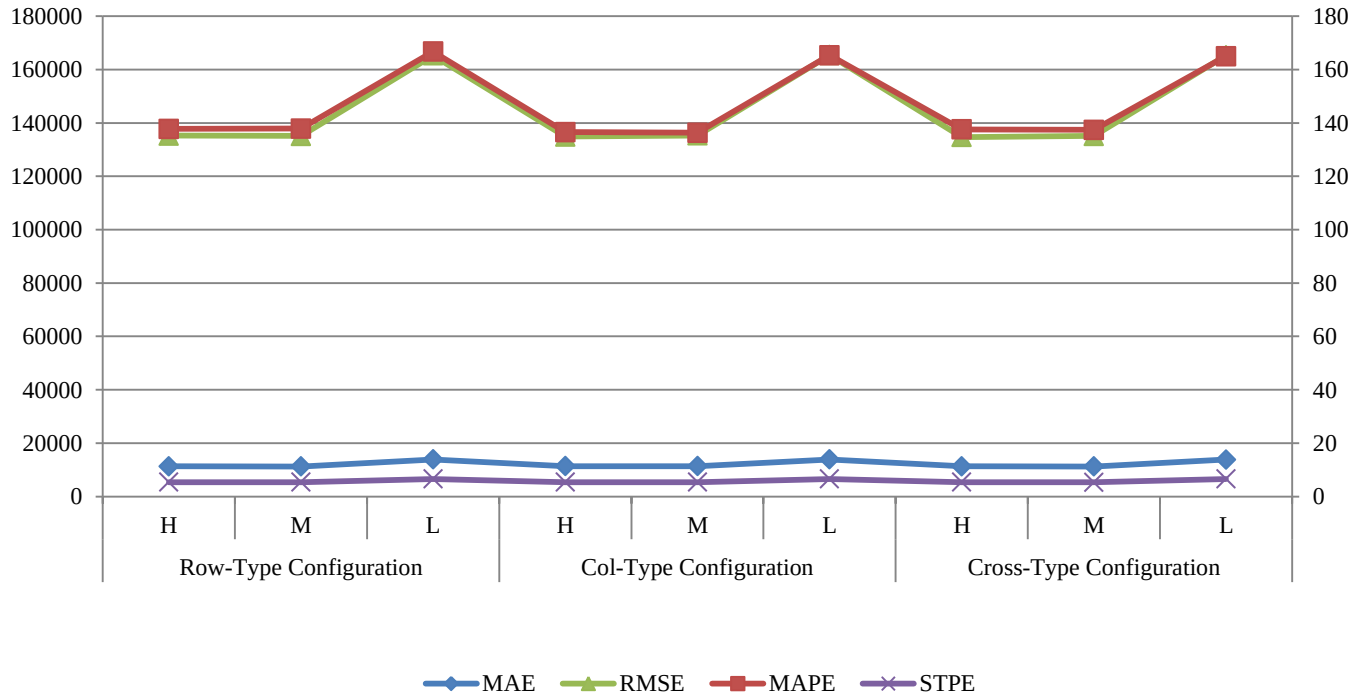
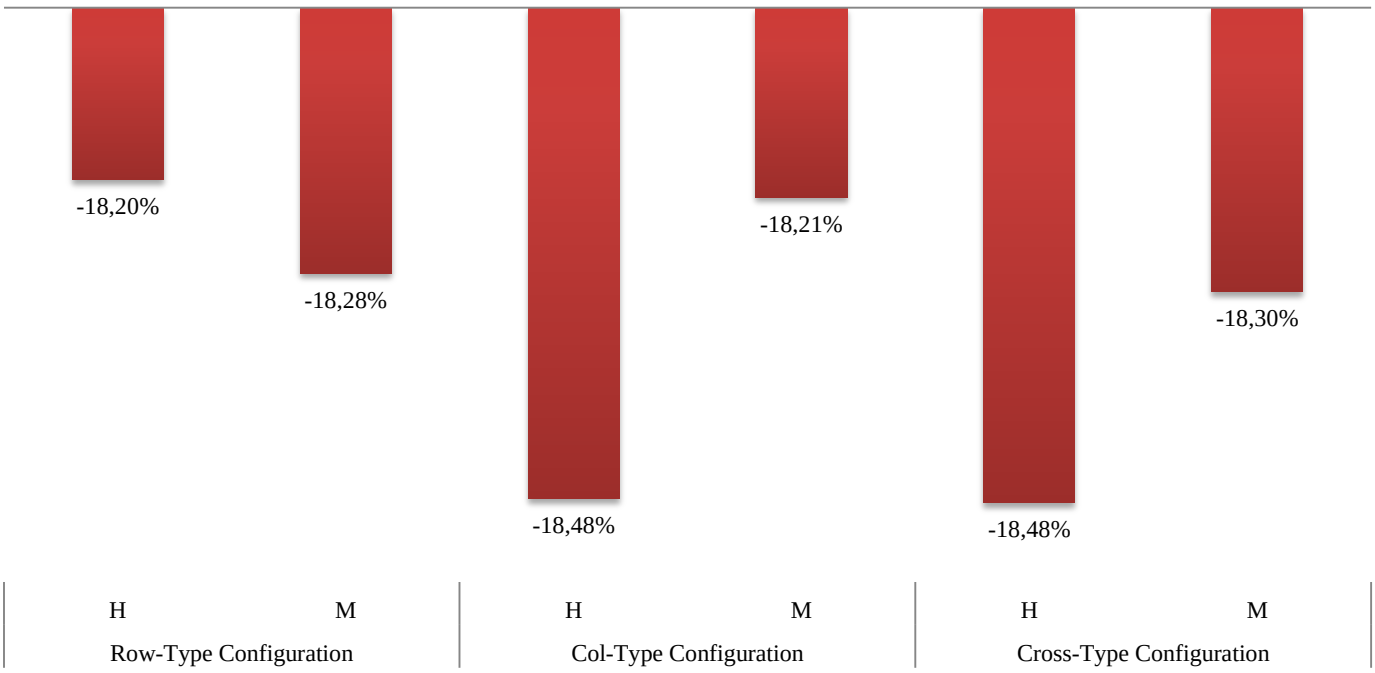


Figure 6 shows that, in terms of absolute level of error for the used indicators, the so-called Low area of the SAM is systematically higher than the other two. More in detail, the High area performance is substantially identical to Mid area (the difference in terms of total errors from the areas go from 0,10% to 0,32%).

Figure 5 - Percentage difference between High and Mid areas of SAM and the Low area



Comparison among multipliers and contribution to error decrease

The complete series of comparison table is reported in the follows:

Table 5- Comparison among multipliers value sum by row for SAM 2005 and contribution to decrease of MAE, MAPE, RMSE and STPE

	row	MAE	MAPE	RMSE	STPE
Prodotti dell'agricoltura, caccia e servizi connessi	9,577	-0,49%	0,11%	-0,26%	-0,49%
Pesca ed altri prodotti ittici; servizi accessori della pesca	1,491	-0,03%	-0,06%	-0,01%	-0,03%
Altri prodotti delle industrie estrattive	1,688	-0,02%	-0,14%	-0,01%	-0,02%
Legno e prodotti del legno e sughero (mobili esclusi)	5,056	-0,07%	-0,29%	-0,02%	-0,07%
Carta e prodotti della carta	5,664	-0,13%	-1,42%	-0,04%	-0,13%
Coke e prodotti della raffinazione del petrolio	9,607	-0,51%	-0,66%	-0,23%	-0,51%
Prodotti chimici e fibre artificiali	21,484	-0,75%	0,27%	-0,37%	-0,75%
Altri minerali non metalliferi	8,626	-0,22%	-0,28%	-0,08%	-0,22%
Macchine ed apparecchi elettrici	7,969	-0,29%	1,60%	-0,07%	-0,29%
Materiale da recupero	1,614	-0,05%	-0,18%	-0,01%	-0,05%
Energia elettrica, gas e vapore	11,798	-0,79%	0,66%	-0,24%	-0,79%
Raccolta e distribuzione dell'acqua	2,084	-0,08%	-0,06%	-0,05%	-0,08%
Costruzioni	28,351	**-5,27%**	3,87%	-0,25%	**-5,27%**
Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	12,088	-0,65%	-0,46%	-0,31%	-0,65%
Alberghi e ristoranti	18,325	-0,43%	0,77%	-0,17%	-0,43%
Trasporti terrestri	16,464	-1,55%	1,08%	**-0,48%**	-1,55%
Trasporti ausiliari; agenzie di viaggio	7,284	-0,33%	0,05%	-0,08%	-0,33%
Intermediazione finanziaria, escluso assicurazione e fondi pensione	12,905	-0,40%	0,81%	-0,15%	-0,40%
Servizi ausiliari di intermediazione finanziaria	5,076	-0,14%	**-5,17%**	**0,01%**	-0,14%
Noleggio di macchinari	4,032	-0,12%	0,12%	-0,01%	-0,12%
Computer e servizi connessi	8,048	-0,27%	2,08%	-0,02%	-0,27%
Ricerca e sviluppo (R&S)	2,770	-0,09%	0,18%	-0,01%	-0,09%
Attività professionali	24,615	-2,03%	-0,66%	-0,25%	-2,03%
Sanità e servizi sociali	18,618	-0,76%	0,73%	-0,34%	-0,76%
Smaltimento rifiuti, fognature e servizi similari	4,568	-0,06%	-0,07%	0,00%	-0,06%
Attività ricreative, culturali e sportive	5,479	-0,28%	0,27%	-0,10%	-0,28%
Altri servizi	4,171	-0,36%	-1,27%	-0,16%	-0,36%

Table 6- Comparison among multipliers value sum by row for SAM 2010 and contribution to decrease of MAE, MAPE, RMSE and STPE

	row	MAE	MAPE	RMSE	STPE
Prodotti dell'agricoltura, caccia e servizi connessi	4,637	-0,49%	0,11%	-0,26%	-0,49%
Pesca ed altri prodotti ittici; servizi accessori della pesca	1,201	-0,03%	-0,06%	-0,01%	-0,03%
Altri prodotti delle industrie estrattive	1,134	-0,02%	-0,14%	-0,01%	-0,02%
Legno e prodotti del legno e sughero (mobili esclusi)	2,158	-0,07%	-0,29%	-0,02%	-0,07%
Carta e prodotti della carta	2,619	-0,13%	-1,42%	-0,04%	-0,13%
Coke e prodotti della raffinazione del petrolio	4,677	-0,51%	-0,66%	-0,23%	-0,51%
Prodotti chimici e fibre artificiali	5,761	-0,75%	0,27%	-0,37%	-0,75%
Altri minerali non metalliferi	2,199	-0,22%	-0,28%	-0,08%	-0,22%
Macchine ed apparecchi elettrici	1,788	-0,29%	1,60%	-0,07%	-0,29%
Materiale da recupero	1,213	-0,05%	-0,18%	-0,01%	-0,05%
Energia elettrica, gas e vapore	7,349	-0,79%	0,66%	-0,24%	-0,79%
Raccolta e distribuzione dell'acqua	1,557	-0,08%	-0,06%	-0,05%	-0,08%
Costruzioni	3,318	**-5,27%**	3,87%	-0,25%	**-5,27%**
Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	5,812	-0,65%	-0,46%	-0,31%	-0,65%

Alberghi e ristoranti	8,442	-0,43%	0,77%	-0,17%	-0,43%
Trasporti terrestri	9,054	-1,55%	1,08%	**-0,48%**	-1,55%
Trasporti ausiliari; agenzie di viaggio	4,581	-0,33%	0,05%	-0,08%	-0,33%
Intermediazione finanziaria, escluso assicurazione e fondi pensione	6,729	-0,40%	0,81%	-0,15%	-0,40%
Servizi ausiliari di intermediazione finanziaria	3,680	-0,14%	**-5,17%**	**0,01%**	-0,14%
Noleggio di macchinari	2,287	-0,12%	0,12%	-0,01%	-0,12%
Computer e servizi connessi	4,540	-0,27%	2,08%	-0,02%	-0,27%
Ricerca e sviluppo (R&S)	1,839	-0,09%	0,18%	-0,01%	-0,09%
Attività professionali	13,508	-2,03%	-0,66%	-0,25%	-2,03%
Sanità e servizi sociali	8,553	-0,76%	0,73%	-0,34%	-0,76%
Smaltimento rifiuti, fognature e servizi similari	2,278	-0,06%	-0,07%	0,00%	-0,06%
Attività ricreative, culturali e sportive	3,371	-0,28%	0,27%	-0,10%	-0,28%
Altri servizi	3,937	-0,36%	-1,27%	-0,16%	-0,36%

Table 7- Comparison among multipliers value sum by column for SAM 2005 and contribution to decrease of MAE, MAPE, RMSE and STPE

	col	MAE	MAPE	RMSE	STPE
Prodotti dell'agricoltura, caccia e servizi connessi	16,774	-0,32%	-0,50%	-0,02%	-0,32%
Pesca ed altri prodotti ittici; servizi accessori della pesca	17,672	-0,02%	-0,01%	0,00%	-0,02%
Altri prodotti delle industrie estrattive	17,533	-0,03%	0,06%	0,00%	-0,03%
Legno e prodotti del legno e sughero (mobili esclusi)	18,772	-0,14%	0,01%	-0,01%	-0,14%
Carta e prodotti della carta	19,095	-0,19%	0,01%	-0,02%	-0,19%
Coke e prodotti della raffinazione del petrolio	19,863	-0,30%	-3,42%	-0,01%	-0,30%
Prodotti chimici e fibre artificiali	19,253	-0,95%	0,48%	-0,24%	-0,95%
Altri minerali non metalliferi	18,851	-0,23%	0,13%	-0,01%	-0,23%
Macchine ed apparecchi elettrici	19,148	-0,29%	0,22%	-0,03%	-0,29%
Materiale da recupero	18,894	-0,02%	-0,07%	0,00%	-0,02%
Energia elettrica, gas e vapore	18,766	-0,36%	-0,19%	-0,02%	-0,36%
Raccolta e distribuzione dell'acqua	18,850	-0,09%	-0,04%	0,00%	-0,09%
Costruzioni	18,399	-1,04%	-0,23%	-0,21%	-1,04%
Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	17,926	-0,49%	0,24%	-0,03%	-0,49%
Alberghi e ristoranti	17,861	-0,29%	-1,51%	-0,02%	-0,29%
Trasporti terrestri	18,011	-0,67%	-1,88%	-0,07%	-0,67%
Trasporti ausiliari; agenzie di viaggio	18,763	-0,36%	-0,19%	-0,03%	-0,36%
Intermediazione finanziaria, escluso assicurazione e fondi pensione	18,660	-0,14%	-0,53%	-0,01%	-0,14%
Servizi ausiliari di intermediazione finanziaria	17,246	-0,07%	-0,32%	0,00%	-0,07%
Noleggio di macchinari	16,291	-0,11%	0,05%	-0,01%	-0,11%
Computer e servizi connessi	18,806	-0,18%	0,01%	-0,01%	-0,18%
Ricerca e sviluppo (R&S)	18,779	-0,03%	**-9,45%**	0,00%	-0,03%
Attività professionali	17,724	-0,45%	-1,10%	-0,07%	-0,45%
Sanità e servizi sociali	19,190	-0,32%	-0,39%	-0,05%	-0,32%
Smaltimento rifiuti, fognature e servizi similari	19,163	-0,10%	-0,11%	0,00%	-0,10%
Attività ricreative, culturali e sportive	18,238	-0,14%	-0,12%	0,00%	-0,14%
Altri servizi	17,982	-0,16%	-0,15%	-0,01%	-0,16%

Table 8- Comparison among multipliers value sum by column for SAM 2005 and contribution to decrease of MAE, MAPE, RMSE and STPE

	col	MAE	MAPE	RMSE	STPE
Prodotti dell'agricoltura, caccia e servizi connessi	8,341	-0,32%	-0,50%	-0,02%	-0,32%
Pesca ed altri prodotti ittici; servizi accessori della pesca	7,596	-0,02%	-0,01%	0,00%	-0,02%
Altri prodotti delle industrie estrattive	7,108	-0,03%	0,06%	0,00%	-0,03%
Legno e prodotti del legno e sughero (mobili esclusi)	8,359	-0,14%	0,01%	-0,01%	-0,14%

Carta e prodotti della carta	8,269	-0,19%	0,01%	-0,02%	-0,19%
Coke e prodotti della raffinazione del petrolio	6,558	-0,30%	-3,42%	-0,01%	-0,30%
Prodotti chimici e fibre artificiali	6,596	-0,95%	0,48%	-0,24%	-0,95%
Altri minerali non metalliferi	9,409	-0,23%	0,13%	-0,01%	-0,23%
Macchine ed apparecchi elettrici	8,292	-0,29%	0,22%	-0,03%	-0,29%
Materiale da recupero	9,852	-0,02%	-0,07%	0,00%	-0,02%
Energia elettrica, gas e vapore	7,617	-0,36%	-0,19%	-0,02%	-0,36%
Raccolta e distribuzione dell'acqua	9,651	-0,09%	-0,04%	0,00%	-0,09%
Costruzioni	9,915	-1,04%	-0,23%	-0,21%	-1,04%
Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	10,110	-0,49%	0,24%	-0,03%	-0,49%
Alberghi e ristoranti	9,631	-0,29%	-1,51%	-0,02%	-0,29%
Trasporti terrestri	9,891	-0,67%	-1,88%	-0,07%	-0,67%
Trasporti ausiliari; agenzie di viaggio	10,489	-0,36%	-0,19%	-0,03%	-0,36%
Intermediazione finanziaria, escluso assicurazione e fondi pensione	9,971	-0,14%	-0,53%	-0,01%	-0,14%
Servizi ausiliari di intermediazione finanziaria	10,045	-0,07%	-0,32%	0,00%	-0,07%
Noleggio di macchinari	9,985	-0,11%	0,05%	-0,01%	-0,11%
Computer e servizi connessi	9,888	-0,18%	0,01%	-0,01%	-0,18%
Ricerca e sviluppo (R&S)	9,832	-0,03%	**-9,45%**	0,00%	-0,03%
Attività professionali	9,875	-0,45%	-1,10%	-0,07%	-0,45%
Sanità e servizi sociali	9,700	-0,32%	-0,39%	-0,05%	-0,32%
Smaltimento rifiuti, fognature e servizi similari	9,918	-0,10%	-0,11%	0,00%	-0,10%
Attività ricreative, culturali e sportive	9,825	-0,14%	-0,12%	0,00%	-0,14%
Altri servizi	9,772	-0,16%	-0,15%	-0,01%	-0,16%

Table 9- Comparison among multipliers value sum by row-column for SAM 2005 and contribution to decrease of MAE, MAPE, RMSE and STPE

	row-col	MAE	MAPE	RMSE	STPE
Prodotti dell'agricoltura, caccia e servizi connessi	25,168	-0,79%	-0,35%	-0,28%	-0,79%
Pesca ed altri prodotti ittici; servizi accessori della pesca	18,152	-0,05%	-0,07%	-0,01%	-0,05%
Altri prodotti delle industrie estrattive	18,210	-0,05%	-0,08%	-0,01%	-0,05%
Legno e prodotti del legno e sughero (mobili esclusi)	22,466	-0,20%	-0,24%	-0,02%	-0,20%
Carta e prodotti della carta	23,521	-0,30%	-1,29%	-0,05%	-0,30%
Coke e prodotti della raffinazione del petrolio	28,309	-0,82%	-3,97%	-0,23%	-0,82%
Prodotti chimici e fibre artificiali	39,112	-1,39%	0,61%	-0,44%	-1,39%
Altri minerali non metalliferi	26,206	-0,43%	-0,14%	-0,09%	-0,43%
Macchine ed apparecchi elettrici	25,899	-0,56%	1,77%	-0,09%	-0,56%
Materiale da recupero	19,494	-0,07%	-0,25%	-0,01%	-0,07%
Energia elettrica, gas e vapore	29,322	-1,10%	0,51%	-0,26%	-1,10%
Raccolta e distribuzione dell'acqua	19,917	-0,17%	-0,10%	-0,05%	-0,17%
Costruzioni	45,104	**-5,74%**	3,77%	-0,32%	**-5,74%**
Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	28,820	-1,11%	-0,28%	-0,33%	-1,11%
Alberghi e ristoranti	34,915	-0,71%	-0,67%	-0,19%	-0,71%
Trasporti terrestri	33,158	-1,92%	-0,55%	**-0,53%**	-1,92%
Trasporti ausiliari; agenzie di viaggio	24,887	-0,69%	-0,14%	-0,10%	-0,69%
Intermediazione finanziaria, escluso assicurazione e fondi pensione	30,328	-0,53%	0,29%	-0,16%	-0,53%
Servizi ausiliari di intermediazione finanziaria	21,077	-0,19%	**-5,19%**	0,00%	-0,19%
Noleggio di macchinari	19,265	-0,23%	0,17%	-0,02%	-0,23%
Computer e servizi connessi	25,620	-0,42%	2,01%	-0,03%	-0,42%
Ricerca e sviluppo (R&S)	20,461	-0,12%	-8,92%	-0,02%	-0,12%
Attività professionali	40,914	-2,36%	-1,59%	-0,29%	-2,36%
Sanità e servizi sociali	36,328	-1,00%	0,23%	-0,37%	-1,00%
Smaltimento rifiuti, fognature e servizi similari	22,315	-0,15%	-0,20%	0,00%	-0,15%
Attività ricreative, culturali e sportive	22,585	-0,39%	0,17%	-0,11%	-0,39%
Altri servizi	21,071	-0,51%	-1,37%	-0,17%	-0,51%

Table 10- Comparison among multipliers value sum by row-column for SAM 2005 and contribution to decrease of MAE, MAPE, RMSE and STPE

	row-col	MAE	MAPE	RMSE	STPE
Prodotti dell'agricoltura, caccia e servizi connessi	12,267	-0,79%	-0,35%	-0,28%	-0,79%
Pesca ed altri prodotti ittici; servizi accessori della pesca	8,101	-0,05%	-0,07%	-0,01%	-0,05%
Altri prodotti delle industrie estrattive	7,551	-0,05%	-0,08%	-0,01%	-0,05%
Legno e prodotti del legno e sughero (mobili esclusi)	9,791	-0,20%	-0,24%	-0,02%	-0,20%
Carta e prodotti della carta	10,183	-0,30%	-1,29%	-0,05%	-0,30%
Coke e prodotti della raffinazione del petrolio	10,839	-0,82%	-3,97%	-0,23%	-0,82%
Prodotti chimici e fibre artificiali	11,802	-1,39%	0,61%	-0,44%	-1,39%
Altri minerali non metalliferi	10,768	-0,43%	-0,14%	-0,09%	-0,43%
Macchine ed apparecchi elettrici	9,331	-0,56%	1,77%	-0,09%	-0,56%
Materiale da recupero	10,203	-0,07%	-0,25%	-0,01%	-0,07%
Energia elettrica, gas e vapore	14,439	-1,10%	0,51%	-0,26%	-1,10%
Raccolta e distribuzione dell'acqua	10,462	-0,17%	-0,10%	-0,05%	-0,17%
Costruzioni	12,342	**-5,74%**	3,77%	-0,32%	**-5,74%**
Commercio, servizi di manutenzione e riparazione di veicoli a motore e motocicli.	15,072	-1,11%	-0,28%	-0,33%	-1,11%
Alberghi e ristoranti	17,188	-0,71%	-0,67%	-0,19%	-0,71%
Trasporti terrestri	18,059	-1,92%	-0,55%	**-0,53%**	-1,92%
Trasporti ausiliari; agenzie di viaggio	14,116	-0,69%	-0,14%	-0,10%	-0,69%
Intermediazione finanziaria, escluso assicurazione e fondi pensione	15,647	-0,53%	0,29%	-0,16%	-0,53%
Servizi ausiliari di intermediazione finanziaria	12,841	-0,19%	**-5,19%**	0,00%	-0,19%
Noleggio di macchinari	11,592	-0,23%	0,17%	-0,02%	-0,23%
Computer e servizi connessi	13,385	-0,42%	2,01%	-0,03%	-0,42%
Ricerca e sviluppo (R&S)	10,586	-0,12%	-8,92%	-0,02%	-0,12%
Attività professionali	22,500	-2,36%	-1,59%	-0,29%	-2,36%
Sanità e servizi sociali	17,135	-1,00%	0,23%	-0,37%	-1,00%
Smaltimento rifiuti, fognature e servizi similari	11,264	-0,15%	-0,20%	0,00%	-0,15%
Attività ricreative, culturali e sportive	12,364	-0,39%	0,17%	-0,11%	-0,39%
Altri servizi	12,769	-0,51%	-1,37%	-0,17%	-0,51%

Appendix 2 - The Error Tables

It seems useful report only the tables related to cumulated cross constraints application, to show the effects on the main aggregates of the matrix as defined in appendix 1.

Cumulated Cross-Type

The following tables contain the absolute difference among the estimated tables using Standard RAS (first table) and Modified RAS with Constraints.
The values are expressed in billions of Euros.

Standard RAS	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	**TOTAL**
LABOUR	0,00	0,00	0,00	0,00	82,46	0,00	0,00	0,00	82,463
CAPITAL	0,00	0,00	0,00	0,00	109,60	0,00	0,00	0,00	109,600
HOUSEHOLDS	0,00	260,38	480,73	258,54	0,00	5,30	0,00	43,48	1048,421
FIRMS	0,00	259,24	0,00	0,00	0,00	6,45	0,00	252,79	518,487
Production sectors	0,00	0,00	434,62	20,37	643,03	65,71	629,21	123,25	1916,197
GOVERNMENT	0,00	1,13	0,41	49,33	39,17	2,86	13,75	0,00	106,652
FIXED CAPITAL FORMATION	0,00	0,00	415,90	328,24	0,00	2,03	0,00	89,69	835,861
REST OF THE WORLD	0,00	0,00	205,44	0,00	271,54	0,00	256,44	0,00	733,416
TOTAL	0,000	520,752	1537,098	656,479	1145,808	82,348	899,395	509,218	

RAS SECTOR 2+37	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	94,64	0,00	0,00	0,00	94,637
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	433,44	261,05	0,00	212,10	0,00	39,71	946,308
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,588
Production sectors	0,00	0,00	395,81	20,32	531,80	60,80	450,44	128,87	1588,038
GOVERNMENT	0,00	0,00	5,64	48,77	47,31	0,88	2,53	0,00	105,123
FIXED CAPITAL FORMATION	0,00	0,00	415,90	330,14	0,00	2,03	0,00	87,79	835,861
REST OF THE WORLD	0,00	0,00	227,72	0,00	272,37	0,00	279,16	0,00	779,253
TOTAL	0,000	0,000	1478,512	660,281	946,114	528,606	732,132	509,162	

RAS SECTOR 37+54	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	76,61	0,00	0,00	0,00	76,605
CAPITAL	0,00	0,00	0,00	0,00	89,27	0,00	0,00	0,00	89,274
HOUSEHOLDS	0,00	260,24	476,52	257,97	0,00	2,97	0,00	44,67	1042,369
FIRMS	0,00	259,07	0,00	0,00	0,00	6,28	0,00	252,79	518,148
Production sectors	0,00	0,00	406,17	20,26	469,57	61,07	434,63	121,04	1512,740
GOVERNMENT	0,00	1,17	3,97	48,99	38,26	2,98	6,63	0,00	102,004
FIXED CAPITAL FORMATION	0,00	0,00	415,90	327,23	0,00	2,03	0,00	90,70	835,861
REST OF THE WORLD	0,00	0,00	217,94	0,00	274,26	0,00	271,67	0,00	763,873
TOTAL	0,000	520,489	1520,497	654,454	947,977	75,328	712,921	509,208	

RAS SECTOR 2+37+54	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	91,68	0,00	0,00	0,00	91,681
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	433,73	261,23	0,00	212,05	0,00	39,55	946,564
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,588
Production sectors	0,00	0,00	386,15	20,24	478,73	60,70	434,71	128,97	1509,488
GOVERNMENT	0,00	0,00	9,10	48,61	38,76	0,89	6,63	0,00	103,987
FIXED CAPITAL FORMATION	0,00	0,00	415,90	330,08	0,00	2,03	0,00	87,85	835,861
REST OF THE WORLD	0,00	0,00	229,36	0,00	262,44	0,00	271,04	0,00	762,845
TOTAL	0,000	0,000	1474,235	660,155	871,611	528,472	712,374	509,166	

RAS SECTOR 2+37+42+54	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	87,64	0,00	0,00	0,00	87,644
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	432,46	260,20	0,00	213,63	0,00	41,37	947,661
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,588
Production sectors	0,00	0,00	368,64	19,94	436,61	58,12	421,86	125,85	1431,020
GOVERNMENT	0,00	0,00	5,75	48,64	38,73	0,86	9,69	0,00	103,676
FIXED CAPITAL FORMATION	0,00	0,00	415,90	328,78	0,00	2,03	0,00	89,15	835,861
REST OF THE WORLD	0,00	0,00	222,48	0,00	261,99	0,00	263,80	0,00	748,275
TOTAL	0,000	0,000	1445,224	657,560	824,972	527,441	695,360	509,168	

RAS SECTOR 2+21+37+42+54	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	85,24	0,00	0,00	0,00	85,240
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	424,57	257,49	0,00	213,15	0,00	46,08	941,287
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,588
Production sectors	0,00	0,00	373,28	19,88	404,45	57,47	414,58	118,00	1387,643
GOVERNMENT	0,00	0,00	3,96	48,30	40,55	0,87	9,59	0,00	103,272
FIXED CAPITAL FORMATION	0,00	0,00	415,90	325,67	0,00	2,03	0,00	92,26	835,861
REST OF THE WORLD	0,00	0,00	242,50	0,00	232,26	0,00	254,23	0,00	728,992
TOTAL	0,000	0,000	1460,214	651,340	762,497	526,311	678,397	509,125	

RAS SECTOR 2+21+37+38+42+54	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	85,65	0,00	0,00	0,00	85,650
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	424,52	256,46	0,00	215,95	0,00	47,88	944,810
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,588
Production sectors	0,00	0,00	356,00	19,75	384,00	53,48	409,45	115,05	1337,717
GOVERNMENT	0,00	0,00	1,44	48,32	41,35	0,82	10,93	0,00	102,849
FIXED CAPITAL FORMATION	0,00	0,00	415,90	324,53	0,00	2,03	0,00	93,40	835,861
REST OF THE WORLD	0,00	0,00	237,27	0,00	234,04	0,00	250,77	0,00	722,079
TOTAL	0,000	0,000	1435,119	649,054	745,035	525,071	671,149	509,128	

RAS SECTOR 2+21+35+37+38+42+54	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	86,74	0,00	0,00	0,00	86,745
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	422,77	256,08	0,00	215,33	0,00	48,64	942,821
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,588
Production sectors	0,00	0,00	354,34	19,64	357,12	52,86	398,97	113,49	1296,428
GOVERNMENT	0,00	0,00	1,56	48,24	42,84	0,83	13,17	0,00	106,642
FIXED CAPITAL FORMATION	0,00	0,00	415,90	323,96	0,00	2,03	0,00	93,97	835,861
REST OF THE WORLD	0,00	0,00	239,94	0,00	224,40	0,00	243,83	0,00	708,172
TOTAL	0,000	0,000	1434,511	647,928	711,109	523,851	655,971	508,888	

RAS SECTOR 2+21+35+37+38+42+54+57	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	77,85	0,00	0,00	0,00	77,850
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	424,86	255,68	0,00	219,32	0,00	50,14	950,000
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,588
Production sectors	0,00	0,00	342,80	18,07	349,93	47,60	385,43	110,19	1254,018
GOVERNMENT	0,00	0,00	1,58	48,40	42,58	0,77	16,38	0,00	109,714
FIXED CAPITAL FORMATION	0,00	0,00	415,90	322,16	0,00	2,03	0,00	95,77	835,861
REST OF THE WORLD	0,00	0,00	231,74	0,00	225,03	0,00	236,26	0,00	693,027
TOTAL	0,000	0,000	1416,878	644,316	695,382	522,517	638,066	508,899	

RAS SECTOR 2+20+21+35+37+38+42+54+57	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	78,79	0,00	0,00	0,00	78,794
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	421,47	254,66	0,00	218,82	0,00	52,01	946,963
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,589
Production sectors	0,00	0,00	341,46	17,99	340,20	46,97	383,03	107,14	1236,789
GOVERNMENT	0,00	0,00	3,40	48,34	38,72	0,77	16,07	0,00	107,304
FIXED CAPITAL FORMATION	0,00	0,00	415,90	320,99	0,00	2,03	0,00	96,94	835,861
REST OF THE WORLD	0,00	0,00	236,18	0,00	217,37	0,00	233,04	0,00	686,594
TOTAL	0,000	0,000	1418,404	641,978	675,089	521,394	632,143	508,885	

RAS SECTOR 2+5+20+21+35+37+38+42+54+57	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	74,76	0,00	0,00	0,00	74,756
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	418,55	253,78	0,00	218,32	0,00	53,56	944,206
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,589
Production sectors	0,00	0,00	335,54	17,95	332,51	46,51	375,25	104,70	1212,454
GOVERNMENT	0,00	0,00	6,15	48,36	40,02	0,77	16,96	0,00	112,256
FIXED CAPITAL FORMATION	0,00	0,00	415,90	320,09	0,00	2,03	0,00	97,84	835,861
REST OF THE WORLD	0,00	0,00	238,35	0,00	208,76	0,00	226,62	0,00	673,734
TOTAL	0,000	0,000	1414,486	640,184	656,046	520,422	618,827	508,889	

RAS SECTOR 2+5+20+21+35+37+38+41+42+54+57	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	71,95	0,00	0,00	0,00	71,950
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	420,20	252,99	0,00	222,37	0,00	55,16	950,714
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,589
Production sectors	0,00	0,00	327,14	17,55	320,39	41,38	368,29	102,02	1176,771
GOVERNMENT	0,00	0,00	8,79	48,45	41,22	0,71	18,47	0,00	117,640
FIXED CAPITAL FORMATION	0,00	0,00	415,90	318,98	0,00	2,03	0,00	98,95	835,861
REST OF THE WORLD	0,00	0,00	233,08	0,00	209,65	0,00	222,24	0,00	664,975
TOTAL	0,000	0,000	1405,111	637,968	643,217	519,280	609,006	508,918	

RAS SECTOR 2+5+20+21+35+37+38+41+42+45+54+57	LABOUR	CAPITAL	HOUSEHOLDS	FIRMS	Production sectors	GOVERNMENT	FIXED CAPITAL FORMATION	REST OF THE WORLD	TOTAL
LABOUR	0,00	0,00	0,00	0,00	71,96	0,00	0,00	0,00	71,960
CAPITAL	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,000
HOUSEHOLDS	0,00	0,00	419,84	252,76	0,00	222,66	0,00	55,59	950,841
FIRMS	0,00	0,00	0,00	0,00	0,00	252,79	0,00	252,79	505,589
Production sectors	0,00	0,00	325,29	17,52	311,61	40,99	363,45	101,34	1160,191
GOVERNMENT	0,00	0,00	9,30	48,45	40,75	0,70	19,48	0,00	118,688
FIXED CAPITAL FORMATION	0,00	0,00	415,90	318,73	0,00	2,03	0,00	99,20	835,861
REST OF THE WORLD	0,00	0,00	232,40	0,00	207,33	0,00	219,24	0,00	658,977
TOTAL	0,000	0,000	1402,731	637,458	631,647	519,180	602,172	508,919	

Appendix3 - The code

Module 1

```
Sub RAS()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 17 novembre 2014
'Release: 1.0

'Questa routine bilancia con il metodo rAs una matrice di tipo SAM 28 per 28
'*************************************************************************************************

 Application.ScreenUpdating = False

 ImportTotals

 Sheets("RAS").Select
Do Until Range("EN5").Value < 0.001
'Riquadra matrice per riga

    Range("BV2:EH66").Select
Selection.Copy
    Range("B2").Select
Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
:=False, Transpose:=False
Application.CutCopyMode = False


'Riquadra matrice per colonna

    Range("B74:BN138").Select
Selection.Copy
    Range("B2").Select
Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
:=False, Transpose:=False
Application.CutCopyMode = False

i = i + 1
  Loop

MsgBox "Matrice bilanciata. Iterazioni effettuate = " & i

    Sheets("RAS").Select
Range("B2:BN66").Select
    With Selection.Interior
        .Pattern = xlSolid
        .PatternColorIndex = xlAutomatic
        .Color = 65535
        .TintAndShade = 0
        .PatternTintAndShade = 0
```

```
    End With
    Range("A1").Select

Sheets("Main").Select
Range("B6").Select

End Sub

Sub Resetta()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 17 novembre 2014
'Release: 1.0

'Questa routine resetta il processo
'*************************************************************************************************

Application.ScreenUpdating = False

Sheets("Old").Select
Range("B2:BN66").Select
Selection.Copy

Sheets("RAS").Select
Range("B2").Select
ActiveSheet.Paste

    Range("B67").Select
    Range(Selection, Selection.End(xlToRight)).Select
    Application.CutCopyMode = False
    Selection.Copy
    Range("B68").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
    Selection.Copy

    Range("BQ2").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=True


    Range("BV2").Select
    Selection.Copy
    Range("BV2:EH66").Select
    ActiveSheet.Paste

Sheets("Main").Select
Range("B6").Select

End Sub
```

```
Sub RASAdvWConstraints()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 06 gennaio 2015 - 13 luglio 2015
'Release: 1.0

'Questa routine bilancia con il metodo rAs una matrice di tipo SAM 65 per 65 con dei vincoli e una variante al
RAS
'*************************************************************************************************

Application.ScreenUpdating = False
Dim SomVinc As Variant
Dim Vinc As Variant
Dim Difference As Variant
Dim CoeFree As Variant

Sheets("Main").Select
Range("M8") = Time

   Sheets("Old2").Select
   Range("BP2:BP66").Select
   Selection.Copy

   Sheets("RASAdv").Select
   Range("BP2").Select
   Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
      :=False, Transpose:=False
   Range("B68").Select
   Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
:=False, Transpose:=True

ImportConstraints

'Vettori riga e colonna dei totali della SAM
TotaliR = Array(LAVOR, CAPIT, FAMIG, IMPRE, Agric, Silvi, Pesca, Carbo, Petro, Estra, Altri, Alibe,
Tabac, Tessi, Vesti, Cuoio, Legno, Carta, Edito, Coke, Chimi, Gomma, Nonme, Metal, Menoa, Macch, Uffpc,
Elett, Radio, Medic, Veico, AlTra, Mobil, Recup, Energ, Racco, Costr, Comme, Ingro, Detta, Alber, Terre,
Marit, Aerei, Ausil, Poste, Inter, Assic, Servi, Immob, Noleg, Compu, Ricer, Profe, Pubbl, Istru, Sanit, Smalt,
Organ, Attiv, AlSer, Domes, GOVER, FCAPI, RESTO)
TotaliC = Array(LAVOR, CAPIT, FAMIG, IMPRE, Agric, Silvi, Pesca, Carbo, Petro, Estra, Altri, Alibe,
Tabac, Tessi, Vesti, Cuoio, Legno, Carta, Edito, Coke, Chimi, Gomma, Nonme, Metal, Menoa, Macch, Uffpc,
Elett, Radio, Medic, Veico, AlTra, Mobil, Recup, Energ, Racco, Costr, Comme, Ingro, Detta, Alber, Terre,
Marit, Aerei, Ausil, Poste, Inter, Assic, Servi, Immob, Noleg, Compu, Ricer, Profe, Pubbl, Istru, Sanit, Smalt,
Organ, Attiv, AlSer, Domes, GOVER, FCAPI, RESTO)

Range("BO2").Select

   For i = 0 To UBound(TotaliR)
      TotaliR(i) = ActiveCell
      TotaliC(i) = ActiveCell
      ActiveCell.Offset(1, 0).Activate
```

```
   Next i

Range("BO2").Select

'Definizione del vettore totale delle variabili della matrice

Matrix

'Acquisizione nuovo target

TotaliRN = Array(LAVOR, CAPIT, FAMIG, IMPRE, Agric, Silvi, Pesca, Carbo, Petro, Estra, Altri, Alibe,
Tabac, Tessi, Vesti, Cuoio, Legno, Carta, Edito, Coke, Chimi, Gomma, Nonme, Metal, Menoa, Macch, Uffpc,
Elett, Radio, Medic, Veico, AlTra, Mobil, Recup, Energ, Racco, Costr, Comme, Ingro, Detta, Alber, Terre,
Marit, Aerei, Ausil, Poste, Inter, Assic, Servi, Immob, Noleg, Compu, Ricer, Profe, Pubbl, Istru, Sanit, Smalt,
Organ, Attiv, AlSer, Domes, GOVER, FCAPI, RESTO)
TotaliCN = Array(LAVOR, CAPIT, FAMIG, IMPRE, Agric, Silvi, Pesca, Carbo, Petro, Estra, Altri, Alibe,
Tabac, Tessi, Vesti, Cuoio, Legno, Carta, Edito, Coke, Chimi, Gomma, Nonme, Metal, Menoa, Macch, Uffpc,
Elett, Radio, Medic, Veico, AlTra, Mobil, Recup, Energ, Racco, Costr, Comme, Ingro, Detta, Alber, Terre,
Marit, Aerei, Ausil, Poste, Inter, Assic, Servi, Immob, Noleg, Compu, Ricer, Profe, Pubbl, Istru, Sanit, Smalt,
Organ, Attiv, AlSer, Domes, GOVER, FCAPI, RESTO)

Range("BP2").Select

   For i = 0 To UBound(TotaliRN)
      TotaliRN(i) = ActiveCell
      TotaliCN(i) = ActiveCell
      ActiveCell.Offset(1, 0).Activate
   Next i

Range("BP2").Select

i = 0




Do Until Range("BV2").Value < 6


         Do Until Range("BT2").Value < 3
'Vettori riga e colonna dei totali della SAM
         TotaliR = Array(LAVOR, CAPIT, FAMIG, IMPRE, Agric, Silvi, Pesca, Carbo, Petro, Estra, Altri,
Alibe, Tabac, Tessi, Vesti, Cuoio, Legno, Carta, Edito, Coke, Chimi, Gomma, Nonme, Metal, Menoa, Macch,
Uffpc, Elett, Radio, Medic, Veico, AlTra, Mobil, Recup, Energ, Racco, Costr, Comme, Ingro, Detta, Alber,
Terre, Marit, Aerei, Ausil, Poste, Inter, Assic, Servi, Immob, Noleg, Compu, Ricer, Profe, Pubbl, Istru, Sanit,
Smalt, Organ, Attiv, AlSer, Domes, GOVER, FCAPI, RESTO)

Range("BO2").Select

            For i = 0 To UBound(TotaliR)
```

```
        TotaliR(i) = ActiveCell
        ActiveCell.Offset(1, 0).Activate
    Next i

'riquadramento per riga

' declare ALL your variables
Dim n As Long, m As Long
Dim ws As Excel.Worksheet

' Explicitly reference the required sheet
Set ws = ActiveSheet ' or ActiveSheet or whatever

' Qualify range references with worksheet
Range("B2").Select

Dim matrixelement(0 To 64, 0 To 64) As Variant

Count = 0

    For n = 0 To 64
    CoeFree = 0
    CoeFreeValue = 0
    SomCoeFreeValue = 0
    SomVinc = 0

        For m = 0 To 64

        If ActiveCell.Interior.Color = 65535 Then
            matrixelement(n, m) = ActiveCell
            Vinc = ActiveCell
            SomVinc = SomVinc + Vinc
            ActiveCell.Offset(0, 1).Activate

            Else

            CoeFree = CoeFree + 1
            CoeFreeValue = ActiveCell
            SomCoeFreeValue = SomCoeFreeValue + CoeFreeValue
            Factor = TotaliRN(n) / TotaliR(n)
            NewCell = ActiveCell
            matrixelement(n, m) = NewCell * Factor
            ActiveCell.Offset(0, 1).Activate
            End If

        Next m

        Constr = 0
        ActiveCell.Offset(0, -m).Activate
        If CoeFree = 0 Then
        Difference = 0
        DifferenceUsed = 0
```

```
                Else
                Difference = (TotaliRN(n) - TotaliR(n))
                End If

                For m = 0 To 64
                If ActiveCell.Interior.Color = 65535 Then
                   matrixelement(n, m) = ActiveCell
                   ActiveCell.Offset(0, 1).Activate

                   Else
                   Ratio = ActiveCell / SomCoeFreeValue
                   DifferenceUsed = Difference * Ratio
                   NewCell = ActiveCell + DifferenceUsed
                   matrixelement(n, m) = NewCell
                   ActiveCell.Offset(0, 1).Activate
                   End If
                Next m
              ActiveCell.Offset(1, -m).Activate
              Next n

        ' Return result to sheet in one go
ws.Range("B2:BN66") = matrixelement

        k = k + 1
          Loop

        Do Until Range("BU2").Value < 3

'Vettori colonna dei totali della SAM
        TotaliC = Array(LAVOR, CAPIT, FAMIG, IMPRE, Agric, Silvi, Pesca, Carbo, Petro, Estra, Altri,
Alibe, Tabac, Tessi, Vesti, Cuoio, Legno, Carta, Edito, Coke, Chimi, Gomma, Nonme, Metal, Menoa, Macch,
Uffpc, Elett, Radio, Medic, Veico, AlTra, Mobil, Recup, Energ, Racco, Costr, Comme, Ingro, Detta, Alber,
Terre, Marit, Aerei, Ausil, Poste, Inter, Assic, Servi, Immob, Noleg, Compu, Ricer, Profe, Pubbl, Istru, Sanit,
Smalt, Organ, Attiv, AlSer, Domes, GOVER, FCAPI, RESTO)

Range("B67").Select

              For i = 0 To UBound(TotaliR)
                 TotaliC(i) = ActiveCell
                 ActiveCell.Offset(0, 1).Activate
              Next i

        'riquadramento per colonna

        ' declare ALL your variables
        Dim p As Long, q As Long
        Dim ws2 As Excel.Worksheet

        ' Explicitly reference the required sheet
        Set ws2 = ActiveSheet ' or ActiveSheet or whatever

        ' Qualify range references with worksheet
```

```
Range("B2").Select

Dim matrixelement2(0 To 64, 0 To 64) As Variant

   Count = 0

      For p = 0 To 64
      CoeFree = 0
      CoeFreeValue = 0
      SomCoeFreeValue = 0
      SomVinc = 0

         For q = 0 To 64

         If ActiveCell.Interior.Color = 65535 Then
         Vinc = ActiveCell
         SomVinc = SomVinc + Vinc
         matrixelement2(q, p) = ActiveCell
         ActiveCell.Offset(1, 0).Activate

         Else

         CoeFree = CoeFree + 1
         CoeFreeValue = ActiveCell
         SomCoeFreeValue = SomCoeFreeValue + CoeFreeValue
         Factor = TotaliCN(p) / TotaliC(p)
         NewCell = ActiveCell
         matrixelement2(q, p) = NewCell * Factor
         ActiveCell.Offset(1, 0).Activate
         End If

         Next q

      ActiveCell.Offset(-q, 0).Activate
      Constr = 0
      If CoeFree = 0 Then
      Difference = 0
      DifferenceUsed = 0
      Else
      Difference = (TotaliCN(p) - TotaliC(p))
      End If

      For q = 0 To 64

      If ActiveCell.Interior.Color = 65535 Then
         matrixelement2(q, p) = ActiveCell
         ActiveCell.Offset(1, 0).Activate

         Else
         Ratio = ActiveCell / SomCoeFreeValue
         DifferenceUsed = Difference * Ratio
         NewCell = ActiveCell + DifferenceUsed
```

```
                matrixelement2(q, p) = NewCell
                ActiveCell.Offset(1, 0).Activate
                End If

            Next q
            ActiveCell.Offset(-q, 1).Activate
            Next p



        ' Return result to sheet in one go
ws2.Range("B2:BN66") = matrixelement2

        k = k + 1
Loop


k = k + 1

Loop

'MsgBox "Matrice bilanciata. Iterazioni effettuate = " & k

Sheets("RASAdv").Select
Range("B2:BN66").Select
   With Selection.Interior
      .Pattern = xlSolid
      .PatternColorIndex = xlAutomatic
      .Color = 65535
      .TintAndShade = 0
      .PatternTintAndShade = 0
   End With

   Columns("B:BN").Select
   Selection.ColumnWidth = 11
   Range("BR2").Select

   Sheets("Old2").Select
   Range("EN2:GZ2").Select
   Range(Selection, Selection.End(xlDown)).Select
   Selection.Copy
   Sheets("RASAdv").Select
   Range("B73").Select
   ActiveSheet.Paste
   Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
      :=False, Transpose:=False



Sheets("Main").Select
Range("M10") = Time
```

```
Range("M12").Select

End Sub

Sub CrossBalancedTest()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 11 luglio 2015
'Release: 1.0

'Questa routine bilancia con il metodo rAsAdv 65 matrici in cui sono vincolati i 65 settori, uno alla volta
'*************************************************************************************************

Application.ScreenUpdating = False


   oldStatusBar = Application.DisplayStatusBar
   Application.DisplayStatusBar = True


Sheets("Main").Select
Range("P8") = Time

Sheets("Cross-Balanced").Select
Range("A1").Select

For i = 0 To 64

Application.StatusBar = "Elaborazione matrice numero " & i

If i = 2 Then GoTo 467
If i = 3 Then GoTo 467
If i = 5 Then GoTo 467
If i = 7 Then GoTo 467
If i = 8 Then GoTo 467
If i = 9 Then GoTo 467
If i = 11 Then GoTo 467
If i = 12 Then GoTo 467
If i = 13 Then GoTo 467
If i = 14 Then GoTo 467
If i = 15 Then GoTo 467
If i = 18 Then GoTo 467
If i = 21 Then GoTo 467
If i = 23 Then GoTo 467
If i = 24 Then GoTo 467
If i = 25 Then GoTo 467
If i = 26 Then GoTo 467
If i = 28 Then GoTo 467
If i = 29 Then GoTo 467
If i = 30 Then GoTo 467
If i = 31 Then GoTo 467
```

```
If i = 32 Then GoTo 467
If i = 38 Then GoTo 467
If i = 39 Then GoTo 467
If i = 42 Then GoTo 467
If i = 43 Then GoTo 467
If i = 45 Then GoTo 467
If i = 47 Then GoTo 467
If i = 49 Then GoTo 467
If i = 54 Then GoTo 467
If i = 55 Then GoTo 467
If i = 58 Then GoTo 467
If i = 61 Then GoTo 467
If i = 62 Then GoTo 467
If i = 63 Then GoTo 467
If i = 64 Then GoTo 467

RestoreRASAdv

Sheets("Old2").Select

    Sheets("Old2").Select
    Range("BX139:EK204").Select
    Selection.Copy
    Range("BX1").Select
    ActiveSheet.Paste

    Range("BY71").Select
    ActiveCell.Offset(i, 0).Activate
    Range(Selection, Selection.End(xlToRight)).Select
    Selection.Copy
    ActiveCell.Offset(-69, 0).Activate
    ActiveSheet.Paste

    Range("BY71").Select
    ActiveCell.Offset(0, i).Activate
    Range(Selection, Selection.End(xlDown)).Select
    Selection.Copy
    ActiveCell.Offset(-69, 0).Activate
    ActiveSheet.Paste

    Range("BY2").Select

    RASAdvWConstraints

    Sheets("RASAdv").Select
    Range("B2:BN66").Select
    Selection.Copy

Sheets("Cross-Balanced").Select
ActiveCell.Select
Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
```

```
ActiveCell.Offset(69, 0).Activate
467
Next i

    Sheets("Old2").Select
    Range("BX139:EK204").Select
    Selection.Copy
    Range("BX1").Select
    ActiveSheet.Paste

Sheets("Main").Select
Range("P10") = Time
Range("P12").Select

End Sub
```

Module 2

```
Sub Matrix()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 06 gennaio 2015 - 13 luglio 2015
'Release: 1.0

'Questa routine riempie una matrice di dimensioni date
'*************************************************************************************************

Application.ScreenUpdating = False

' declare ALL your variables
Dim n As Long, m As Long
Dim ws As Excel.Worksheet

' specify type for all variables, otherwise they will be Variant
Dim Sigmai As Single, Sigmaj As Single, Rho As Single

' Explicitly reference the required sheet
Set ws = ActiveSheet ' or ActiveSheet or whatever

' qualify range references with worksheet
Range("B2").Select

Dim matrixelement(1 To 65, 1 To 65) As Variant

   For n = 1 To 65
      For m = 1 To 65
         matrixelement(n, m) = ActiveCell
         ActiveCell.Offset(0, 1).Activate
      Next m
      ActiveCell.Offset(1, -m + 1).Activate
   Next n

' return result to sheet in one go
  ws.Range("B2:BN66") = matrixelement


End Sub

Sub RestoreRASAdv()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 06 gennaio 2015 - 13 luglio 2015
'Release: 1.0

'Questa routine ripristina l'area di lavoro della variante RAS
'*************************************************************************************************
```

```
Application.ScreenUpdating = False

    Sheets("Old2").Select
    Range("A1:BN66").Select
    Selection.Copy
    Sheets("RASAdv").Select
    Range("A1").Select
    ActiveSheet.Paste

    Sheets("Old2").Select
    Columns("BP:BP").Select
    Selection.Copy
    Sheets("RASAdv").Select
    Columns("BP:BP").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
    Sheets("Old2").Select
    Rows("68:68").Select
    Selection.Copy
    Sheets("RASAdv").Select
    Rows("68:68").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False

    Columns("BR:BV").EntireColumn.AutoFit

    ResetConstraints

    Sheets("RASAdv").Select
    Range("B73").Select
    ActiveCell.FormulaR1C1 = "0"
    Selection.Copy
    Range("B73:BN137").Select
    ActiveSheet.Paste
    Application.CutCopyMode = False
    With Selection.Interior
        .Pattern = xlNone
        .TintAndShade = 0
        .PatternTintAndShade = 0
    End With
    Range("B73").Select


    Range("BR2").Select

    Sheets("Main").Select
    Range("P10") = Time

End Sub

Sub HighlightConstraints()
```

```
'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 06 gennaio 2015 - 13 luglio 2015
'Release: 1.0

'Questa routine evidenzia i vincoli
'*************************************************************************************************

Application.ScreenUpdating = False

ResetConstraints

Sheets("Old2").Select
Range("BS2").Select
NormalRate = ActiveCell
Range("EN2").Select

   For n = 1 To 65
      For m = 1 To 65
         Var = ActiveCell
         ActiveCell.Offset(0, -142).Activate
         Var2 = ActiveCell
         ActiveCell.Offset(0, 142).Activate

            If Var <> Var2 * (1 + NormalRate) Or Var = 0 Then
            ActiveCell.Interior.Color = 65535
            ActiveCell.Offset(0, 1).Activate
            Else
            ActiveCell.Offset(0, 1).Activate
            End If
      Next m
      ActiveCell.Offset(1, -65).Activate
   Next n

Range("EN2").Select

End Sub

Sub ResetConstraints()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 06 gennaio 2015 - 13 luglio 2015
'Release: 1.0

'Questa routine ripristina la matrice dove sono riportati i vincoli
'*************************************************************************************************

Application.ScreenUpdating = False

   Sheets("Old2").Select
```

```
    Range("EN2").Select
    Range(Selection, Selection.End(xlToRight)).Select
    Range(Selection, Selection.End(xlDown)).Select
    With Selection.Interior
        .Pattern = xlNone
        .TintAndShade = 0
        .PatternTintAndShade = 0
    End With
    Range("EN2").Select
End Sub

Sub ImportTotals()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 17 novembre 2014
'Release: 1.0

'Questa routine importa i totali di cornice per il RAS standard
'*************************************************************************************************

Application.ScreenUpdating = False

    Sheets("Old2").Select
    Range("BP2:BP66").Select
    Selection.Copy

    Sheets("RAS").Select
    Range("BQ2").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
    Range("B68").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=True


End Sub

Sub ImportConstraints()

'*************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 06 gennaio 2015 - 13 luglio 2015
'Release: 1.0

'Questa routine importa i vincoli
'*************************************************************************************************

Application.ScreenUpdating = False
HighlightConstraints

    Sheets("Old2").Select
```

```
    Range("EN2:GZ66").Select
    Selection.Copy

    Sheets("RASAdv").Select
    Range("B2").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
    Selection.PasteSpecial Paste:=xlPasteFormats, Operation:=xlNone, _
        SkipBlanks:=False, Transpose:=False

End Sub

Sub ContaVincoli()

'************************************************************************************************
'Autori : Marco Rao e Maria Cristina Tommasino
'Data   : 13 luglio 2015
'Release: 1.0

'Questa routine conta le celle vincolate
'************************************************************************************************

Application.ScreenUpdating = False

Sheets("Old2").Select
Range("EN2").Select

    For n = 1 To 65
        For m = 1 To 65
            Var = ActiveCell

                If ActiveCell.Interior.Color = 65535 Then
                Count = Count + 1
                ActiveCell.Offset(0, 1).Activate
                Else
                ActiveCell.Offset(0, 1).Activate
                End If
        Next m
        ActiveCell.Offset(1, -65).Activate
    Next n

Range("HC2") = Count
End Sub
```

Appendix 4 - More detail on Pearson Correlation Test between multipliers values and accuracy gain

The Pearson coefficient is the classical linear correlation coefficient, well suited to measures the degree of linear correlation between two variables. The squared Pearson correlation coefficient gives an idea of how much of the variability of a variable is explained by the other variable. The p-values that are computed for each coefficient allow testing the null hypothesis that the coefficients are not significantly different from 0. However, one needs to be cautious when interpreting these results, as if two variables are independent, their correlation coefficient is zero, but the reciprocal is not true.

The Pearson correlation test executed between multipliers values and shows what follows.

Row test type group

Test between sum of the multipliers by row for SAM 2005 and MAE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,491	28,351	9,609	7,366
MAE	27	0	27	-0,053	0,000	-0,006	0,010

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,774
MAE	-0,774	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	< 0,0001
MAE	< 0,0001	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,599
MAE	0,599	**1**

Test between sum of the multipliers by row for SAM 2010 and MAE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,134	13,508	4,379	2,999
MAE	27	0	27	-0,053	0,000	-0,006	0,010

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,337
MAE	-0,337	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,085
MAE	0,085	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,114
MAE	0,114	**1**

Test between sum of the multipliers by row for SAM 2005 and MAPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,491	28,351	9,609	7,366
MAE	27	0	27	-0,052	0,039	0,001	0,015

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	0,430
MAE	0,430	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,025
MAE	0,025	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,184
MAE	0,184	**1**

Test between sum of the multipliers by row for SAM 2010 and MAPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,134	13,508	4,379	2,999
MAE	27	0	27	-0,052	0,039	0,001	0,015

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	0,079
MAE	0,079	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,694
MAE	0,694	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,006
MAE	0,006	**1**

Test between sum of the multipliers by row for SAM 2005 and RMSE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,491	28,351	9,609	7,366
MAE	27	0	27	-0,005	0,000	-0,001	0,001

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,763
MAE	-0,763	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	< 0,0001
MAE	< 0,0001	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,583
MAE	0,583	**1**

Test between sum of the multipliers by row for SAM 2010 and RMSE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,134	13,508	4,379	2,999
MAE	27	0	27	-0,005	0,000	-0,001	0,001

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,719
MAE	-0,719	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	< 0,0001
MAE	< 0,0001	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,517
MAE	0,517	**1**

Test between sum of the multipliers by row for SAM 2005 and STPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,491	28,351	9,609	7,366
MAE	27	0	27	-0,053	0,000	-0,006	0,010

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,774
MAE	-0,774	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	< 0,0001
MAE	< 0,0001	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,599
MAE	0,599	**1**

Test between sum of the multipliers by row for SAM 2010 and STPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	1,134	13,508	4,379	2,999
MAE	27	0	27	-0,053	0,000	-0,006	0,010

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,337
MAE	-0,337	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,085
MAE	0,085	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,114
MAE	0,114	**1**

Column test type group

Test between sum of the multipliers by column for SAM 2005 and MAE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	16,291	19,863	18,389	0,822
MAE	27	0	27	-0,010	0,000	-0,003	0,003

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,120
MAE	-0,120	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,551
MAE	0,551	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,014
MAE	0,014	**1**

Test between sum of the multipliers by column for SAM 2010 and MAE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	6,558	10,489	9,129	1,165
MAE	27	0	27	-0,010	0,000	-0,003	0,003

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	0,101
MAE	0,101	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,616
MAE	0,616	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,010
MAE	0,010	**1**

Test between sum of the multipliers by column for SAM 2005 and MAPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	16,291	19,863	18,389	0,822
MAE	27	0	27	-0,094	0,005	-0,007	0,019

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,136
MAE	-0,136	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,500
MAE	0,500	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,018
MAE	0,018	**1**

Test between sum of the multipliers by column for SAM 2010 and MAPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	6,558	10,489	9,129	1,165
MAE	27	0	27	-0,094	0,005	-0,007	0,019

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,054
MAE	-0,054	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,791
MAE	0,791	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,003
MAE	0,003	**1**

Test between sum of the multipliers by column for SAM 2005 and RMSE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	16,291	19,863	18,389	0,822
MAE	27	0	27	-0,002	0,000	0,000	0,001

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,146
MAE	-0,146	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,468
MAE	0,468	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,021
MAE	0,021	**1**

Test between sum of the multipliers by column for SAM 2010 and RMSE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	6,558	10,489	9,129	1,165
MAE	27	0	27	-0,002	0,000	0,000	0,001

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	0,167
MAE	0,167	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,406
MAE	0,406	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,028
MAE	0,028	**1**

Test between sum of the multipliers by column for SAM 2005 and STPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	16,291	19,863	18,389	0,822
MAE	27	0	27	-0,010	0,000	-0,003	0,003

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,120
MAE	-0,120	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,551
MAE	0,551	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,014
MAE	0,014	**1**

Test between sum of the multipliers by column for SAM 2010 and STPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	6,558	10,489	9,129	1,165
MAE	27	0	27	-0,010	0,000	-0,003	0,003

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	0,101
MAE	0,101	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,616
MAE	0,616	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,010
MAE	0,010	**1**

Row-Column test type group

Test between sum of the multipliers by row and column for SAM 2005 and MAE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	18,152	45,104	26,764	7,328
MAE	27	0	27	-0,057	0,000	-0,008	0,011

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	**-0,807**
MAE	**-0,807**	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	< **0,0001**
MAE	< **0,0001**	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,652
MAE	0,652	**1**

Test between sum of the multipliers by row and column for SAM 2010 and MAE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	7,551	22,500	12,689	3,315
MAE	27	0	27	-0,057	0,000	-0,008	0,011

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	**-0,384**
MAE	**-0,384**	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	**0,048**
MAE	**0,048**	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,148
MAE	0,148	**1**

Test between sum of the multipliers by row and column for SAM 2005 and MAPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	18,152116	45,103872	26,763797	7,3279103
MAE	27	0	27	-0,089173	0,0376918	-0,0058695	0,0234002

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	0,3174246
MAE	0,317	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,107
MAE	0,107	**0,000**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,101
MAE	0,101	**1,000**

Test between sum of the multipliers by row and column for SAM 2010 and MAPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	7,551	22,500	12,689	3,314510
MAE	27	0	27	-0,089	0,038	-0,006	0,023400

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	0,025
MAE	0,025	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,901
MAE	0,901	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,001
MAE	0,001	**1**

Test between sum of the multipliers by row and column for SAM 2005 and RMSE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	18,152	45,104	26,764	7,328
MAE	27	0	27	-0,005	0,000	-0,002	0,002

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,790
MAE	-0,790	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	< 0,0001
MAE	< 0,0001	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,625
MAE	0,625	**1**

Test between sum of the multipliers by row and column for SAM 2010 and RMSE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	7,551	22,500	12,689	3,315
MAE	27	0	27	-0,005	0,000	-0,002	0,002

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,616
MAE	-0,616	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,001
MAE	0,001	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,379
MAE	0,379	**1**

Test between sum of the multipliers by row and column for SAM 2005 and STPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	18,152	45,104	26,764	7,328
MAE	27	0	27	-0,057	0,000	-0,008	0,011

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,807
MAE	-0,807	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	< 0,0001
MAE	< 0,0001	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,652
MAE	0,652	**1**

Test between sum of the multipliers by row and column for SAM 2010 and STPE decreasing

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
row-col	27	0	27	7,551	22,500	12,689	3,315
MAE	27	0	27	-0,057	0,000	-0,008	0,011

Correlation matrix (Pearson):

Variables	row-col	MAE
row-col	**1**	-0,384
MAE	-0,384	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	row-col	MAE
row-col	**0**	0,048
MAE	0,048	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (R^2):

Variables	row-col	MAE
row-col	**1**	0,148
MAE	0,148	**1**

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