



**STATISTICS DIRECTORATE**

**National Accounts and Financial Statistics Division**

**The use of class size and the Italian method**

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Workshop on measuring Education and Health Volume

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## **The use of class size and the Italian method**

### **Introduction**

This document presents the method used for the estimation, in volume terms, of the non market education services provided by general government sector. The implementation of the output methods, suggested by statistical literature and the quality corrections used so far will be illustrated by means of the data used and the main results.

A short description of the story of the output methods implementation in the Italian National accounts is useful for understanding the rationale behind the methods and the choices. The institutional framework for the supply of the services and the recent years' changes, guiding some of the choices, will also be described.

As far as quality measures are concerned education, stratified by level, is probably the area in which further advancements have been reached. The changes in the institutional settings, due to reform of the university courses/degrees that has happened in the last period, should be carefully taken into account to avoid misinterpretation of the final outcome.

The pros and cons of the choices represent an integral part of work. Nevertheless, any conclusion shouldn't leave out the output measures that are actually disposable from the statistical data sources.

### **European comparisons of government expenditure on education: an overview**

The importance of government production in the framework of the production of the total economy can be measured by using a simple indicator represented by the ratio of Government final consumption expenditure to GDP. The following table<sup>1</sup> presents this indicator for the main European countries<sup>2</sup>.

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<sup>1</sup> This table and the other tables of this paragraph have been prepared by using data extracted from the Eurostat database as of 16<sup>th</sup> May 2007. The corresponding table of ESA95 questionnaire is Table 1102 *Public expenditure by function*.

<sup>2</sup> The countries on the tables are related to the definition of EU15 used for the measurement of the European aggregated until the entrance of the new member states in 2006.

## Final consumption expenditure as a percentage of GDP

| Geo            | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|----------------|------|------|------|------|------|------|
| Austria        | 18,4 | 18,2 | 18,2 | 18,3 | 18,1 | 18,1 |
| Belgium        | 21,3 | 21,8 | 22,5 | 23,0 | -    | -    |
| Denmark        | 25,1 | 25,7 | 26,2 | 26,5 | 26,6 | 25,9 |
| Finland        | 20,3 | 20,4 | 21,0 | 21,7 | 21,9 | 22,1 |
| France         | 22,9 | 22,8 | 23,4 | 23,7 | 23,7 | 23,7 |
| Germany        | 19,0 | 18,9 | 19,2 | 19,3 | 18,8 | 18,7 |
| Greece         | 17,3 | 16,8 | 17,5 | 16,4 | 16,5 | 0,0  |
| Ireland        | 13,8 | 14,7 | 15,1 | 15,3 | 15,8 | -    |
| Italy          | 18,4 | 19,0 | 19,2 | 19,7 | 19,8 | 20,2 |
| Luxembourg     | 15,1 | 16,1 | 16,2 | 16,4 | 17,1 | 17,0 |
| Netherlands    | 22,0 | 22,6 | 23,7 | 24,5 | 24,3 | 24,1 |
| Portugal       | 19,3 | 19,7 | 20,0 | 20,3 | 20,6 | 21,1 |
| Spain          | -    | -    | -    | -    | -    | -    |
| Sweden         | 26,4 | 26,9 | 27,8 | 28,1 | 27,5 | -    |
| United Kingdom | 19,1 | 19,5 | 20,3 | 21,0 | 21,3 | 21,8 |

It can be observed that, on average, Government final consumption expenditure represents 20% of GDP, having a maximum for Sweden, more than 27% in the most recent years, and a minimum for Ireland, at around 15 per cent in the same period.

Going in the detail of the composition of the Final consumption expenditure it can be noted that education is 22% on average, reaching its maximum for Portugal, 30% of the Total, and the minimum for Ireland and UK, that spend 17% of P3 on education.

### Education % of Final consumption expenditure

| Geo            | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|----------------|------|------|------|------|------|------|
| Austria        | 28,3 | 28,4 | 28,3 | 28,3 | 27,8 | 27,7 |
| Belgium        | 25,5 | 25,6 | 25,4 | 25,0 | -    | -    |
| Denmark        | 23,3 | 23,1 | 23,2 | 23,0 | 23,6 | 23,5 |
| Germany        | 18,3 | 18,3 | 18,5 | 18,6 | 18,7 | 18,5 |
| Ireland        | 16,7 | 16,1 | 16,4 | 17,2 | 17,2 | -    |
| Greece         | 17,7 | 19,9 | 19,9 | 23,5 | 23,1 | -    |
| Spain          | -    | -    | -    | -    | -    | -    |
| France         | 22,3 | 22,0 | 22,0 | 21,7 | 20,7 | 20,6 |
| Italy          | 22,5 | 22,0 | 21,7 | 21,7 | 20,3 | 20,8 |
| Luxembourg     | 24,2 | 24,0 | 24,2 | 24,2 | 23,9 | 23,2 |
| Netherlands    | 18,0 | 18,4 | 18,3 | 18,3 | 18,5 | 18,8 |
| Portugal       | 30,0 | 29,9 | 30,3 | 29,8 | 29,4 | 29,2 |
| Finland        | 21,4 | 21,6 | 20,9 | 20,7 | 20,5 | 20,2 |
| Sweden         | 22,8 | 23,4 | 23,6 | 23,5 | 24,6 | -    |
| United Kingdom | 17,4 | 17,6 | 17,7 | 17,4 | 17,2 | 16,9 |

The expenditures for education service are mainly related to the provision of the service itself; the following table, showing the ratio between final consumption expenditure and total expenditure, is helpful to comprehend this trend. Actually, it can be noted the strong predominance of P3 to the total expenditure for education.

| Geo            | 2000 | 2001  | 2002  | 2003  | 2004  | 2005 |
|----------------|------|-------|-------|-------|-------|------|
| Austria        | 88,2 | 88,1  | 86,9  | 87,0  | 84,0  | 84,0 |
| Belgium        | 96,4 | 96,9  | 96,9  | 97,0  | -     | -    |
| Denmark        | 73,5 | 73,3  | 73,9  | 74,1  | 76,2  | 76,6 |
| Germany        | 82,6 | 82,4  | 82,7  | 83,0  | 83,2  | 83,6 |
| Ireland        | 56,9 | 54,9  | 58,2  | 61,2  | 60,0  | -    |
| Greece         | 95,2 | 110,7 | 109,3 | 109,2 | 111,5 | -    |
| Spain          | -    | -     | -     | -     | -     | -    |
| France         | 81,0 | 79,3  | 80,4  | 81,2  | 79,5  | 79,1 |
| Italy          | 89,4 | 89,1  | 88,7  | 87,8  | 87,5  | 88,7 |
| Luxembourg     | 84,8 | 84,6  | 82,6  | 80,5  | 78,7  | 78,3 |
| Netherlands    | 84,4 | 86,3  | 85,9  | 86,2  | 86,3  | 88,2 |
| Portugal       | 86,2 | 84,8  | 83,6  | 82,2  | 81,9  | 82,9 |
| Finland        | 74,6 | 74,1  | 73,9  | 72,6  | 73,6  | 74,0 |
| Sweden         | 88,3 | 87,2  | 88,7  | 90,0  | 90,8  | -    |
| United Kingdom | 67,1 | 65,4  | 63,2  | 63,0  | 63,5  | 63,5 |

In order to have an idea of the importance of this function with respect to the total public expenditure (defined as of EU Regulation 1500/2000) some evidences can be deduced from the following table:

**Education: expenditure as a percentage of Total expenditure**

| Geo            | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|----------------|------|------|------|------|------|------|
| Austria        | 11,5 | 11,5 | 11,7 | 11,7 | 11,9 | 12,0 |
| Belgium        | 11,5 | 11,7 | 11,8 | 11,6 | -    | -    |
| Denmark        | 14,7 | 14,8 | 14,9 | 14,8 | 14,9 | 15,0 |
| Germany        | 9,3  | 8,9  | 9,0  | 8,9  | 9,0  | 8,9  |
| Ireland        | 12,8 | 12,9 | 12,7 | 12,8 | 13,3 | -    |
| Greece         | 6,3  | 6,1  | 6,5  | 7,2  | 6,9  | 5,9  |
| Spain          | 11,2 | 11,2 | 11,3 | 11,4 | 11,4 | 11,5 |
| France         | 12,2 | 12,3 | 12,2 | 11,9 | 11,6 | 11,5 |
| Italy          | 10,0 | 9,7  | 9,9  | 10,1 | 9,7  | 9,9  |
| Luxembourg     | 11,5 | 12,0 | 11,5 | 11,7 | 11,9 | 11,6 |
| Netherlands    | 10,6 | 10,7 | 10,9 | 11,0 | 11,2 | 11,3 |
| Portugal       | 15,6 | 15,6 | 16,4 | 16,2 | 15,9 | 15,7 |
| Finland        | 12,1 | 12,4 | 12,2 | 12,3 | 12,1 | 12,0 |
| Sweden         | 12,0 | 12,7 | 12,8 | 12,6 | 13,1 | -    |
| United Kingdom | 12,4 | 12,9 | 13,5 | 13,3 | 13,2 | 13,0 |

On average European countries devote more than 11 % of their total government expenditure to education, with a maximum of 16 % for Portugal and a minimum of 6 % for Greece.

## **The evolution of government output evaluation at constant prices**

The measurement of government output is included in the theoretical framework of the national accounts evaluation in volume terms. Since the very beginning of ESA95 introduction the Italian National accounts adopted, for the non market sector, measures based on output methods<sup>3</sup>.

The general revision of the National Accounts made it possible to examine the deflation methods of the economic aggregates relatively to the non-market part, by trying to use, where the data sources presented enough details, methodologies that provided for output indicators, especially as regards the economic activities for which the non-market components is more important than the market one and that are related to the provision of individual services, such as health and education.

The input methods are mainly used for the economic activities that offer collective type services, for which it is not so straightforward to obtain measurements of volume that represent the phenomenon. As regards the individual kind of services, it has been often possible to obtain, with a good approximation level, measurements of volume that allow directly deflating the production.

The main innovations introduced for the public component in the National Account revision<sup>4</sup>, regarded:

- A new framework for the calculation of the production of Government, determining the new structure implemented according the supply and use scheme.
- The examination and the reclassification, where necessary, in an exhaustive way of the distribution of public employment derived from the 8th Census of the Institutions by NACE classification.
- The construction, for each institution or group of institutions concerned, of the bridge-matrices between functions (third level of COFOG classification) and the CPA (fifth digit) for the different kind of public institutions<sup>5</sup>.
- A better specification of the research and development activities performed by Government units, particularly for the Universities based on the results<sup>6</sup> of the Scientific Research survey.
- The determination, also for the institutional units belonging to the Government sector as it happens for the market units, of secondary productions that, in the supply matrix, are represented as figures outside of the diagonal.

## **The institutional framework for the supply of the services and the recent years' changes**

The public production of educational services is divided into the followings activity areas:

- School system
- Vocational training

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<sup>3</sup> For reference please consult Certomà, Lo Moro, Malizia (1995), Collesi (1999, 2000, 2006)

<sup>4</sup> For further details on the revision see Collesi et al (2006)

<sup>5</sup> The 14 groups of institutions considered are as follow: State, Institutions providing cultural services and assistance at the central level, Research bodies, Economic services producers, Regions and autonomous provinces, Provinces, Municipalities, Mountains development bodies, Chambers of commerce, Other local producers of economic services, Institutions providing education, cultural services and assistance at the local level, Local health units and Hospitals, Social security funds.

<sup>6</sup> This calculation is based on the employees of the university devoted to research activities or to didactic activities.

- University education
- Subsidiary services to education

The index used for estimate the output at the prices of the previous year is the Laspeyres volume index, in which the weights are the unitary costs of the single types of service produced, incurred in the previous year by the service provider, and the quantities are represented by the quantity indicators calculated on the basis of the number of students. The index used for the synthesis represents a summary of the indices relative to each type of service. The corrections for the quality changes are included in the calculation of the indices concerning scholastic education and university education.

The following table indicates the composition of current expenditure for the production of educational services by kind of service. The relevance of scholastic education is evident as also the fact that it drives the global index.

| <b>Type of service</b>                  | <b>2000</b>  | <b>2001</b>  | <b>2002</b>  | <b>2003</b>  | <b>2004</b>  | <b>2005</b>  | <b>2006</b>  |
|---|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <i>School system</i>                    | 87,2         | 86,7         | 86,5         | 86,8         | 85,7         | 85,6         | 85,6         |
| <i>Vocational training</i>              | 4,3          | 4,5          | 4,3          | 4,1          | 4,7          | 4,5          | 4,6          |
| <i>University education</i>             | 8,1          | 8,3          | 8,7          | 8,6          | 9,1          | 9,1          | 9,0          |
| <i>Subsidiary services to education</i> | 0,4          | 0,5          | 0,6          | 0,6          | 0,6          | 0,8          | 0,8          |
| <b>Total</b>                            | <b>100,0</b> | <b>100,0</b> | <b>100,0</b> | <b>100,0</b> | <b>100,0</b> | <b>100,0</b> | <b>100,0</b> |

### **School system**

Public school system is organized through the provision of education operated by state<sup>7</sup> schools and other public schools at the local level.

Scholastic education is supplied mainly in state schools, and is divided into four levels: pre-primary education, primary education, lower secondary and upper secondary education.

In the volume index the quantities are represented by the number of pupils in state schools and non-state schools.

The index is calculated at the most detailed level of analysis. The number of students of state and non-state schools is broken down into the four levels of education and, in upper secondary education, by type of institute: classical lyceum, scientific lyceum, teacher-training institutes and schools, vocational institutes, technical institutes, art institutes, art lyceums. Detailed breakdown of the basic data is essential in order to ensure homogeneity among the elementary indices and the costs assigned to them.

The corrective factor for variations in quality of the service offered is based on the number of pupils per class. The quality correction is done according to the education level.

<sup>7</sup> The state schools are local units of the Ministry of Education and the other public schools are local units of the local authorities (Municipalities, Provinces and Regions).

At the basis of correction<sup>8</sup> for the congestion of classes, one finds the theory that, from a certain level of production onwards, the quality of service supplied tends to diminish. The semi-public nature of the educational service implies that it is plausible to suppose that as the number of students per class increases, the individual attention that a teacher may dedicate to each of them decreases. Based on these observations, a conversion function was constructed, which takes on a linear form for the indicator values below the level at which congestion starts, and a non-linear form, similar to a conventional production function, for higher values. Furthermore, the function reaches its maximum in the point of maximum capacity, beyond which the service is overcrowded.

The conversion function transforms the actual number of pupils into a number of "standard or real" pupils who have received a service that can be defined as "standard" quality. The variation with respect to the previous year in the number of standard pupils is used to correct the quantity indicator based on the actual number of pupils. The correction takes place, for each level of education, on the numerator of the index<sup>9</sup>. As an example the conversion function for primary school is presented here. The other conversion functions can be seen on the appendix.

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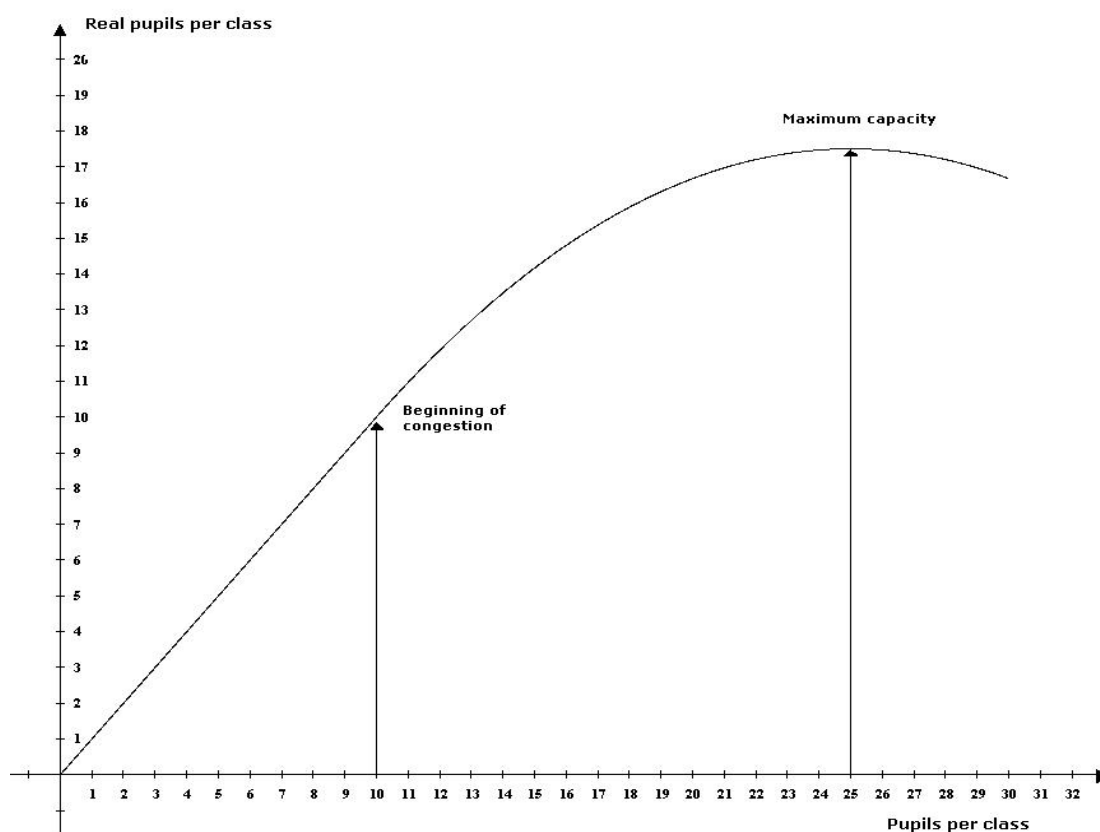
<sup>8</sup> - D. Guerrucci (ISTAT), Volume indices of of non-market education services supplied by General government sector, paper presented at the meeting of Eurostat Task Force on price and volume measures for Education

- D. Guerrucci in: G. A. Certomà, V. Lo Moro, R. Malizia (a cura di), Misura e valutazione dei servizi pubblici , Il Mulino, 1995

<sup>9</sup> In defining the conversion function, the minimum and maximum number of pupils per class was inserted as parameters. The dispositions that regulate the number of pupils per class (or sections for preschool education), are contained in the Ministerial Decree n° 331, 24 July 1998, and include a minimum of 10 pupils per class in the primary schools, up to a max of 25 for all schools except for the upper secondary schools, for which differentiated rules are contemplated for the different types.

**Figure 1: Estimate of conversion function for primary education**

$$q = f(n) = \begin{cases} n & 0 \leq n \leq 10 \\ -1/30n^2 + 5/3n - 10/3 & n > 10 \end{cases} \quad \max f(n) = f(25)$$



All data used for the quality correction, the number of students and the number of classes in state and non-state schools, are available up to the most recent year of the series under examination.

The breakdown of the data on quantities by level of education is consistent with the structure of the costs of production. These are analysed by function, according to the Cofog classification<sup>10</sup>. The classification of educational services in the COFOG nomenclature is based on the categories defined according to the ISCED 97<sup>11</sup> classification. The individual services, classes 9.1.1 up to 9.6.0, are listed below:

- Pre-primary education (9.1.1)
- Primary education (9.1.2)
- Lower-secondary education (9.2.1)

<sup>10</sup> The costs, used as weights in the index, are based on data prepared for the public expenditure by function (ESA95 Questionnaire Table 11) provided to Eurostat according to the EU Regulation on ESA95 Transmission programme.

<sup>11</sup> Isced 97 is the latest version of the International Standard Classification of Education, used by Oecd, Unesco and Eurostat in the production of statistical indicators on education for international comparison.

- Upper-secondary education (9.2.2)
- Post-secondary non tertiary education (9.3.0)
- First stage of tertiary education (9.4.1)
- Second stage of tertiary education (9.4.2)
- Education not definable by level (9.5.0)
- Services subsidiary to education (9.6.0)

The volume index for school system used is a Laspeyres index, which takes on the following form:

$$\frac{\sum_{i=1}^{n.\_of\_levels\_of\_education} (p_{i,(t-1)} \cdot q_{i,(t-1)}) \cdot \frac{q_{i,t}}{q_{i,(t-1)}}}{\sum p_{i,(t-1)} \cdot q_{i,(t-1)}} = \frac{\sum_{i=1}^{n.\_of\_levels\_of\_education} p_{i,(t-1)} \cdot q_{i,t}}{\sum p_{i,(t-1)} \cdot q_{i,(t-1)}}$$

Where:

*i* is the level of education (pre-primary, primary etc)  
*t*=2000...2006 adopting predominance criteria, the generic school year (*t-1*)/*t* corresponds to the year *t*

$\frac{q_{i,t}}{q_{i,(t-1)}}$  quantity indicator<sup>12</sup> of level of education *i*

$(p_{i,(t-1)} \cdot q_{i,(t-1)})$  weight associated to level of education *i* in the year *t-1*; because these are non-market services, their cost is the weight

At the numerator, for each level of education, the value of production is calculated at the previous year's prices. The index might be separately calculated for state education and for non-state education.

### University education

The production of services supplied by universities is split in two CPA classes<sup>13</sup>: Research and Development, for the part related to research, and Education, for the part concerning didactic services. Research and development services are deflated using an input method, while the education component is deflated with the output method.

In the Italian university system there not exists an obligation of attendance for all the courses, there is no standard number of courses to be attended during the academic year and there are no obstacles to pass from one year to the next.

This situation makes impossible to carry out statistical and/or administrative surveys that give an estimation of the teaching hours received by each enrolled student; similarly to the case of scholastic education, it is not possible to apply Eurostat's recommendation.

<sup>12</sup> The indicator has been already corrected for quality.

<sup>13</sup> The division of university production is based on a research carried out by Istat about time length that university professors involve in didactics and research.

This is the reason why the quantity indicator used is the number of enrolled students<sup>14</sup> per faculty and/or group of homogenous faculties (see Appendix 2), hereafter recalled as faculty.

The most relevant changes due to the reform are:

- The introduction of two levels of university degree: the degree course lasting three years, and the specialised degree course.
- The possibility of enrolment in a year other than the first one considering the number of credits acquired through professional experience.
- The possibility for students who enrolled under the old system to pass to the courses set up with the new system having a different legal duration.
- The simultaneous presence of degree courses according the old system and the new one.

Given the updated and more exhaustive data-set, with the benchmark revision<sup>15</sup>, it has been possible to calculate a per capita average cost for 18 faculties. This allows capturing the specific nature of each faculty. The model used for estimating the unitary cost per student is defined by using a methodology based on the standard cost per student<sup>16</sup>. The method for per capita cost calculation would benefit in future, from accountability according to cost centres that is going to be implemented by several universities. For the description of the data used see Appendix 3.

### **Volume index**

The index used for the university production is a PPY Laspeyres volume index, in which the weight is the per capita cost in the year t-1 and the quantity, referring to the current year t, is the number of enrolled students per faculty.

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<sup>14</sup> The total number of enrolled students was used because starting from the academic year 2000/2001 the new didactic system came into force, and as a consequence the data concerning students in the courses are not homogenous for the period examined, provided that they are related to two different kind of university organisation. In the Italian case it was impossible to use the OECD classification of the university system because the areas do not take into account the faculties, but directly classify the various study courses.

<sup>15</sup> Before the benchmark revision, the stratification of faculties regarded 7 groups of faculties, see: Misura e Valutazione dei servizi pubblici, Il Mulino, Bologna 1995, edited by G. Certomà, V. Lo Moro, R. Malizia; in particular see paragraph 2.4 L'Istruzione universitaria. , Istat calculated the average unitary cost per student starting from the unitary costs per faculty of the University "La Sapienza" of Rome.

<sup>16</sup> This methodology has been developed by the "Observatory for the Evaluation of the University System", Ministry of Education, Universities and Research. Please see "Il riparto della quota di equilibrio del fondo per il finanziamento ordinario delle università. Proposte per il triennio 1998 – 2000", DOC 3/98, Ministry of Education, University and Research, Observatory for the evaluation of the university system, June 1998. Calcolo degli indici di costo standard per studente, statistical annex to DOC 3/98, Ministry of Education, University and Research, Observatory for the evaluation of the university system, June 1998.

The index takes on the following form:

$$L_{t/t-1} = \frac{\sum_{j=1}^{18} C_{j,(t-1)} \cdot S_{j,t}}{\sum_{j=1}^{18} C_{j,(t-1)} \cdot S_{j,(t-1)}}$$

where:

$t$  is the time unit

$C$  is the unitary cost of a student of the faculty  $j$

$S$  is the number of students enrolled in the faculty  $j$ .

### Quality indicators

According to Eurostat recommendation a qualitative correction, measuring the outcome of university, was applied in the volume component. The literature presents various indicators<sup>17</sup>, that allow evaluating the results of university production, but it does not give a unique method to measure the efficiency and/or effectiveness of the university. Two indicators have been selected for this correction:

- The ratio between the enrolled “regular students” in the course SCjt and the total number of enrolled students Sjt
- The reduction of the distance between the actual number of years for graduation LEjt and the theoretical length LTjt.

Regular students (students who did not exceed the legal length of their degree) were calculated considering the year of first registration in the Italian university. This is not valid for students enrolled in specialised degree courses, introduced with the new didactic system. The indicator is at maximum equal to 1 if all enrolled students are attending their proper year of attendance. Those faculties for which the indicator is close to 1 are the most efficient.

The actual time for graduation is calculated for graduates from each degree, considering the year of first registration and then grouping by faculty the various actual times. The theoretical time was calculated considering the legal length of every degree attended by graduates, and then again grouping them by faculty. The correlation between theoretical time and actual time is 1 if all students graduate within the legal duration of the course. In this case, too, the index close to 1 means that the university education process has an effective result.

Being that the two indicators have the same direction, they both tend to 1, the simplest aggregation to measure the efficiency and/or effectiveness of the educational procedures has been preferred, supposing that both indicators have the same weight.

<sup>17</sup>

See: Analisi di efficienza ed efficacia del sistema universitario italiano attraverso nuove metodologie statistiche multivariate robuste, RDR 3/04, Ministry of Education, University and Research, Observatory for the evaluation of the university system, April 2004. It is worth noticing that the analysis applied by the Committee serves the purpose of measuring the effectiveness and/or efficiency for each Italian athenaeum.

The corrective factor applied is:

$$q_{j,t} / q_{j,(t-1)}$$

where

$$q_{jt} = ((SC_{jt} / S_{jt}) + (LT_{jt} / LE_{jt})) / 2 \quad [5]$$

The following tables show the quality indicators calculated for the reference period.

**Table 4: Enrolled students, enrolled regular students and distance from an effective situation per faculty**

| Groups                        | Years                 |                                |                  |                       |                                |                  |                       |                                |                  |                       |                                |                  |                       |                                |                  |                       |                                |                  |
|-------------------------------|-----------------------|--------------------------------|------------------|-----------------------|--------------------------------|------------------|-----------------------|--------------------------------|------------------|-----------------------|--------------------------------|------------------|-----------------------|--------------------------------|------------------|-----------------------|--------------------------------|------------------|
|                               | 2000                  |                                |                  | 2001                  |                                |                  | 2002                  |                                |                  | 2003                  |                                |                  | 2004                  |                                |                  | 2005                  |                                |                  |
|                               | Enrolled students (S) | Enrolled regular students (SC) | Ratio (SC) / (S) | Enrolled students (S) | Enrolled regular students (SC) | Ratio (SC) / (S) | Enrolled students (S) | Enrolled regular students (SC) | Ratio (SC) / (S) | Enrolled students (S) | Enrolled regular students (SC) | Ratio (SC) / (S) | Enrolled students (S) | Enrolled regular students (SC) | Ratio (SC) / (S) | Enrolled students (S) | Enrolled regular students (SC) | Ratio (SC) / (S) |
| 01 Sciences                   | 125.259               | 73.199                         | 0,58             | 124.760               | 73.187                         | 0,59             | 127.695               | 76.188                         | 0,60             | 133.360               | 81.099                         | 0,61             | 139.885               | 85.604                         | 0,61             | 143.799               | 85.678                         | 0,60             |
| 02 Pharmacy                   | 42.412                | 28.567                         | 0,67             | 43.779                | 29.161                         | 0,67             | 44.207                | 28.775                         | 0,65             | 46.567                | 30.455                         | 0,65             | 48.553                | 32.570                         | 0,67             | 52.781                | 35.327                         | 0,67             |
| 03 Medicine and Surgery       | 97.220                | 71.312                         | 0,73             | 101.264               | 76.102                         | 0,75             | 116.412               | 89.891                         | 0,77             | 123.898               | 95.519                         | 0,77             | 132.785               | 101.999                        | 0,77             | 139.872               | 106.339                        | 0,76             |
| 04 Engineering                | 209.534               | 123.123                        | 0,59             | 211.330               | 124.087                        | 0,59             | 216.832               | 128.010                        | 0,59             | 224.309               | 131.774                        | 0,59             | 229.145               | 131.336                        | 0,57             | 229.995               | 129.031                        | 0,56             |
| 05 Architecture               | 78.866                | 35.344                         | 0,45             | 75.158                | 35.455                         | 0,47             | 75.367                | 37.174                         | 0,49             | 75.852                | 39.772                         | 0,52             | 77.158                | 42.864                         | 0,56             | 77.186                | 43.037                         | 0,56             |
| 06 Agriculture                | 27.204                | 18.631                         | 0,68             | 26.883                | 17.933                         | 0,65             | 27.611                | 16.823                         | 0,61             | 28.837                | 17.236                         | 0,60             | 29.729                | 17.157                         | 0,58             | 29.608                | 16.655                         | 0,56             |
| 07 Veterinary Medicine        | 13.794                | 8.306                          | 0,60             | 13.571                | 7.906                          | 0,58             | 13.757                | 7.791                          | 0,57             | 14.143                | 8.229                          | 0,58             | 14.605                | 8.691                          | 0,60             | 14.841                | 8.619                          | 0,58             |
| 08 Sociology                  | 22.243                | 15.029                         | 0,68             | 24.777                | 16.947                         | 0,68             | 23.002                | 14.929                         | 0,65             | 14.713                | 7.358                          | 0,50             | 15.196                | 8.044                          | 0,53             | 17.749                | 8.569                          | 0,48             |
| 09 Political science          | 90.044                | 46.895                         | 0,50             | 90.194                | 46.280                         | 0,51             | 91.872                | 49.093                         | 0,53             | 95.943                | 54.318                         | 0,57             | 101.900               | 60.671                         | 0,60             | 100.815               | 56.522                         | 0,56             |
| 10 Law                        | 265.301               | 123.919                        | 0,47             | 252.358               | 113.280                        | 0,45             | 241.830               | 107.687                        | 0,45             | 234.532               | 106.149                        | 0,45             | 230.518               | 107.700                        | 0,47             | 227.507               | 97.259                         | 0,43             |
| 11 Letter                     | 216.385               | 120.072                        | 0,55             | 212.600               | 119.173                        | 0,56             | 220.379               | 125.242                        | 0,57             | 242.890               | 145.265                        | 0,60             | 247.190               | 148.733                        | 0,60             | 249.607               | 137.357                        | 0,55             |
| 12 Language                   | 42.716                | 25.566                         | 0,60             | 45.475                | 28.046                         | 0,62             | 48.939                | 29.967                         | 0,61             | 52.120                | 32.218                         | 0,62             | 53.859                | 33.360                         | 0,62             | 55.796                | 31.251                         | 0,56             |
| 13 Cultural Heritage          | 7.201                 | 4.635                          | 0,64             | 7.259                 | 4.591                          | 0,63             | 7.261                 | 4.006                          | 0,55             | 7.396                 | 3.725                          | 0,50             | 7.390                 | 3.360                          | 0,45             | 6.663                 | 2.574                          | 0,39             |
| 14 Psychology                 | 31.475                | 19.888                         | 0,63             | 30.170                | 19.057                         | 0,63             | 35.386                | 24.008                         | 0,68             | 44.220                | 30.497                         | 0,69             | 45.825                | 31.408                         | 0,69             | 48.375                | 29.485                         | 0,61             |
| 15 Economics                  | 214.706               | 111.559                        | 0,52             | 206.755               | 107.894                        | 0,52             | 205.534               | 111.484                        | 0,54             | 207.555               | 117.379                        | 0,57             | 210.493               | 121.594                        | 0,58             | 207.215               | 114.205                        | 0,55             |
| 16 Education                  | 82.970                | 54.181                         | 0,65             | 91.576                | 61.340                         | 0,67             | 102.301               | 68.904                         | 0,67             | 96.624                | 61.678                         | 0,64             | 106.464               | 65.306                         | 0,61             | 111.138               | 64.455                         | 0,58             |
| 17 Statistics                 | 6.622                 | 3.447                          | 0,52             | 6.146                 | 3.223                          | 0,52             | 5.366                 | 2.818                          | 0,53             | 4.746                 | 2.537                          | 0,53             | 4.316                 | 2.567                          | 0,59             | 4.000                 | 2.479                          | 0,62             |
| 18 Exercise and Sport Science | 4.026                 | 2.704                          | 0,67             | 5.151                 | 4.018                          | 0,78             | 6.717                 | 5.525                          | 0,82             | 7.619                 | 6.201                          | 0,81             | 9.540                 | 7.020                          | 0,74             | 13.105                | 8.673                          | 0,66             |
| Total                         | 1.580.978             | 886.467                        | 0,56             | 1.569.206             | 887.340                        | 0,57             | 1.610.468             | 928.315                        | 0,58             | 1.655.324             | 971.409                        | 0,59             | 1.704.141             | 1.009.984                      | 0,59             | 1.730.052             | 977.515                        | 0,57             |

**Table 5: Actual and theoretical average time for degree, average reduction of distance from the theoretical time per faculty**

| Groups                        | Years                           |                                      |                                   |                                 |                                      |                                   |                                 |                                      |                                   |                                 |                                      |                                   |                                 |                                      |                                   |                                 |                                      |                                   |
|-------------------------------|---------------------------------|--------------------------------------|-----------------------------------|---------------------------------|--------------------------------------|-----------------------------------|---------------------------------|--------------------------------------|-----------------------------------|---------------------------------|--------------------------------------|-----------------------------------|---------------------------------|--------------------------------------|-----------------------------------|---------------------------------|--------------------------------------|-----------------------------------|
|                               | 2000                            |                                      |                                   | 2001                            |                                      |                                   | 2002                            |                                      |                                   | 2003                            |                                      |                                   | 2004                            |                                      |                                   | 2005                            |                                      |                                   |
|                               | Actual time for graduation (LE) | Theoretical time for graduation (LT) | Reduction of distance (LT) / (LE) | Actual time for graduation (LE) | Theoretical time for graduation (LT) | Reduction of distance (LT) / (LE) | Actual time for graduation (LE) | Theoretical time for graduation (LT) | Reduction of distance (LT) / (LE) | Actual time for graduation (LE) | Theoretical time for graduation (LT) | Reduction of distance (LT) / (LE) | Actual time for graduation (LE) | Theoretical time for graduation (LT) | Reduction of distance (LT) / (LE) | Actual time for graduation (LE) | Theoretical time for graduation (LT) | Reduction of distance (LT) / (LE) |
| 01 Sciences                   | 10,18                           | 4,65                                 | 0,46                              | 8,77                            | 4,56                                 | 0,52                              | 8,02                            | 4,27                                 | 0,53                              | 7,67                            | 4,13                                 | 0,54                              | 6,90                            | 3,91                                 | 0,57                              | 6,59                            | 3,63                                 | 0,55                              |
| 02 Pharmacy                   | 11,07                           | 4,98                                 | 0,45                              | 8,91                            | 4,90                                 | 0,55                              | 8,75                            | 4,87                                 | 0,56                              | 8,47                            | 4,84                                 | 0,57                              | 7,94                            | 4,75                                 | 0,60                              | 8,15                            | 4,68                                 | 0,57                              |
| 03 Medicine and Surgery       | 7,52                            | 5,88                                 | 0,78                              | 7,18                            | 4,50                                 | 0,63                              | 6,32                            | 4,01                                 | 0,63                              | 6,05                            | 3,92                                 | 0,65                              | 5,88                            | 3,79                                 | 0,64                              | 5,65                            | 3,71                                 | 0,66                              |
| 04 Engineering                | 12,78                           | 5,00                                 | 0,39                              | 9,31                            | 4,73                                 | 0,51                              | 8,59                            | 4,53                                 | 0,53                              | 7,67                            | 4,27                                 | 0,56                              | 6,97                            | 4,05                                 | 0,58                              | 6,86                            | 3,92                                 | 0,56                              |
| 05 Architecture               | 15,05                           | 4,98                                 | 0,33                              | 10,21                           | 4,89                                 | 0,48                              | 9,42                            | 4,75                                 | 0,50                              | 8,28                            | 4,46                                 | 0,54                              | 8,02                            | 4,39                                 | 0,55                              | 7,51                            | 4,10                                 | 0,55                              |
| 06 Agriculture                | 11,60                           | 5,00                                 | 0,43                              | 8,33                            | 4,73                                 | 0,57                              | 7,86                            | 4,50                                 | 0,57                              | 7,80                            | 4,41                                 | 0,56                              | 7,38                            | 4,20                                 | 0,57                              | 7,35                            | 3,92                                 | 0,53                              |
| 07 Veterinary Medicine        | 12,20                           | 5,00                                 | 0,41                              | 9,11                            | 4,03                                 | 0,54                              | 9,17                            | 4,87                                 | 0,53                              | 8,57                            | 4,85                                 | 0,57                              | 8,59                            | 4,75                                 | 0,55                              | 8,30                            | 4,60                                 | 0,55                              |
| 08 Sociology                  | 7,68                            | 4,15                                 | 0,54                              | 7,79                            | 3,99                                 | 0,51                              | 7,61                            | 3,97                                 | 0,52                              | 8,06                            | 3,87                                 | 0,48                              | 7,89                            | 3,80                                 | 0,48                              | 7,78                            | 3,65                                 | 0,47                              |
| 09 Political science          | 8,67                            | 4,00                                 | 0,46                              | 8,32                            | 3,89                                 | 0,47                              | 8,15                            | 3,85                                 | 0,47                              | 7,73                            | 3,81                                 | 0,49                              | 6,64                            | 3,61                                 | 0,54                              | 5,90                            | 3,40                                 | 0,58                              |
| 10 Law                        | 8,65                            | 4,00                                 | 0,46                              | 9,07                            | 3,98                                 | 0,44                              | 9,13                            | 3,97                                 | 0,44                              | 8,93                            | 3,75                                 | 0,42                              | 8,24                            | 3,81                                 | 0,46                              | 8,02                            | 3,74                                 | 0,47                              |
| 11 Letter                     | 8,47                            | 4,04                                 | 0,48                              | 8,55                            | 4,01                                 | 0,47                              | 8,32                            | 3,95                                 | 0,48                              | 7,90                            | 3,92                                 | 0,50                              | 7,16                            | 3,76                                 | 0,53                              | 6,95                            | 3,60                                 | 0,52                              |
| 12 Language                   | 8,46                            | 4,00                                 | 0,47                              | 8,25                            | 3,93                                 | 0,48                              | 8,00                            | 3,92                                 | 0,49                              | 7,50                            | 3,84                                 | 0,51                              | 6,88                            | 3,72                                 | 0,54                              | 6,77                            | 3,53                                 | 0,52                              |
| 13 Cultural Heritage          | 8,46                            | 4,00                                 | 0,47                              | 9,17                            | 3,97                                 | 0,43                              | 8,57                            | 3,94                                 | 0,46                              | 8,31                            | 3,89                                 | 0,47                              | 8,24                            | 3,83                                 | 0,46                              | 8,08                            | 3,70                                 | 0,46                              |
| 14 Psychology                 | 10,03                           | 5,00                                 | 0,50                              | 8,88                            | 5,00                                 | 0,56                              | 8,83                            | 4,96                                 | 0,56                              | 7,26                            | 4,50                                 | 0,62                              | 6,43                            | 4,24                                 | 0,66                              | 6,26                            | 3,87                                 | 0,62                              |
| 15 Economics                  | 8,76                            | 4,00                                 | 0,46                              | 8,65                            | 3,90                                 | 0,45                              | 8,12                            | 3,83                                 | 0,47                              | 7,56                            | 3,75                                 | 0,50                              | 6,75                            | 3,63                                 | 0,54                              | 6,72                            | 3,46                                 | 0,51                              |
| 16 Education                  | 7,40                            | 4,09                                 | 0,55                              | 7,26                            | 3,96                                 | 0,55                              | 7,00                            | 3,82                                 | 0,55                              | 7,01                            | 3,81                                 | 0,54                              | 6,78                            | 3,82                                 | 0,56                              | 6,71                            | 3,69                                 | 0,55                              |
| 17 Statistics                 | 7,84                            | 4,00                                 | 0,51                              | 7,36                            | 3,74                                 | 0,51                              | 6,92                            | 3,56                                 | 0,52                              | 6,55                            | 3,56                                 | 0,54                              | 6,21                            | 3,45                                 | 0,56                              | 5,75                            | 3,27                                 | 0,57                              |
| 18 Exercise and Sport Science | 4,00                            | 4,00                                 | 1,00                              | 4,14                            | 3,34                                 | 0,81                              | 5,15                            | 3,38                                 | 0,66                              | 3,76                            | 3,40                                 | 0,90                              | 4,48                            | 3,42                                 | 0,76                              | 4,93                            | 3,24                                 | 0,66                              |
| Total                         | 9,75                            | 4,43                                 | 0,45                              | 8,63                            | 4,26                                 | 0,49                              | 8,15                            | 4,13                                 | 0,51                              | 7,65                            | 4,00                                 | 0,52                              | 7,00                            | 3,87                                 | 0,55                              | 6,78                            | 3,69                                 | 0,54                              |

**Table 6: Synthetic quality indicator, as of formula 5**

| Groups                        | Years |      |      |      |      |      |
|-------------------------------|-------|------|------|------|------|------|
|                               | 2000  | 2001 | 2002 | 2003 | 2004 | 2005 |
| 01 Sciences                   | 0,52  | 0,55 | 0,56 | 0,57 | 0,59 | 0,57 |
| 02 Pharmacy                   | 0,56  | 0,61 | 0,60 | 0,61 | 0,63 | 0,62 |
| 03 Medicine and Surgery       | 0,76  | 0,69 | 0,70 | 0,71 | 0,71 | 0,71 |
| 04 Engineering                | 0,49  | 0,55 | 0,56 | 0,57 | 0,58 | 0,56 |
| 05 Architecture               | 0,39  | 0,48 | 0,50 | 0,53 | 0,55 | 0,55 |
| 06 Agriculture                | 0,56  | 0,61 | 0,59 | 0,58 | 0,57 | 0,55 |
| 07 Veterinary Medicine        | 0,51  | 0,56 | 0,55 | 0,57 | 0,57 | 0,57 |
| 08 Sociology                  | 0,61  | 0,60 | 0,59 | 0,49 | 0,51 | 0,48 |
| 09 Political science          | 0,48  | 0,49 | 0,50 | 0,53 | 0,57 | 0,57 |
| 10 Law                        | 0,46  | 0,44 | 0,44 | 0,44 | 0,46 | 0,45 |
| 11 Letter                     | 0,52  | 0,51 | 0,52 | 0,55 | 0,56 | 0,53 |
| 12 Language                   | 0,54  | 0,55 | 0,55 | 0,56 | 0,58 | 0,54 |
| 13 Cultural Heritage          | 0,56  | 0,53 | 0,51 | 0,49 | 0,46 | 0,42 |
| 14 Psychology                 | 0,57  | 0,60 | 0,62 | 0,65 | 0,67 | 0,61 |
| 15 Economics                  | 0,49  | 0,49 | 0,51 | 0,53 | 0,56 | 0,53 |
| 16 Education                  | 0,60  | 0,61 | 0,61 | 0,59 | 0,59 | 0,56 |
| 17 Statistics                 | 0,52  | 0,52 | 0,52 | 0,54 | 0,58 | 0,59 |
| 18 Exercise and Sport Science | 0,84  | 0,79 | 0,74 | 0,86 | 0,75 | 0,66 |
| Total                         | 0,51  | 0,53 | 0,54 | 0,55 | 0,57 | 0,55 |

It is worth noticing that the choice of only two indicators for the quality adjustment, also whether several indicators could be theoretically calculated, has been limited in order to have a simpler and understandable synthetic indicator.

The PPY Laspeyres volume index, corrected with the quality factor for the part concerning university education, becomes:

$$L_{t/t-1} = \frac{\sum_{j=1}^{18} c_{j,(t-1)} \cdot s_{j,t} \cdot \frac{q_{j,t}}{q_{j,(t-1)}}}{\sum_{j=1}^{18} c_{j,(t-1)} \cdot s_{j,(t-1)}}$$

where:

t is the time unit

C is the unitary cost of a student of the faculty j

S is the number of students enrolled in the faculty j

q is quality indicators in the faculty j

### **Conclusions and future works**

Several kinds of quality corrections have been suggested by the statistical literature and, on the other hand, a lot of work has been done on the pragmatic point of view, without reaching a unique conclusion. The quality, having multidimensional characteristics, is by far one of the most difficult, even if fascinating, issue to be conveyed through figures.

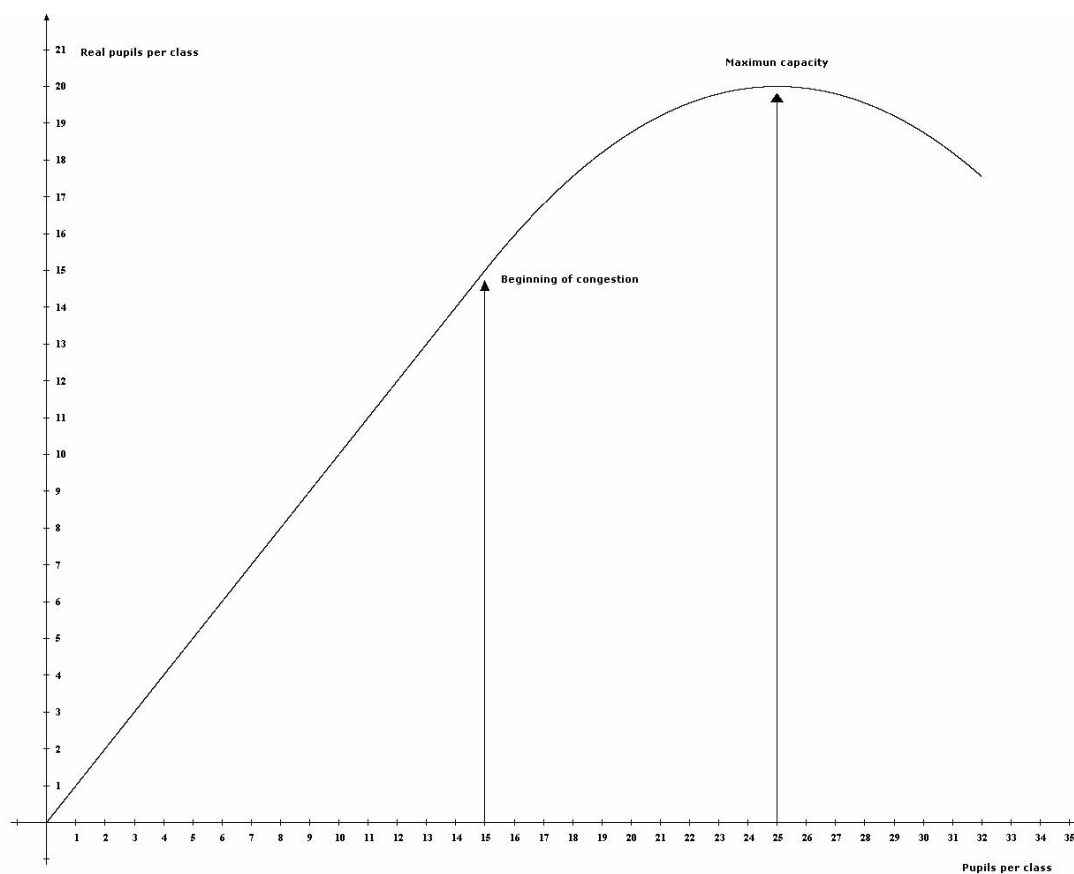
The topic of international comparison of volume measures for non-market services is very important and whatever kind of correction for quality does affect the final result, also doing no correction at all. The sensitiveness of this issue is now receiving a great attention from the international organisations, which are among the main users of these figures. In our opinion, a possible suggestion to reach a satisfactory conclusion for all the countries could be to provide a score for the quality corrections, as it actually happens for the methods (A/B/C) to be used according to Eurostat Handbook, in order to determine the best correction, the other acceptable corrections and the corrections not to be used. Furthermore, to make the producers of these data able to use the suggested methodology, statistical surveys, especially deemed to respond to the measurement of quality dimensions, should be implement in the national statistical programmes.

## APPENDIX 1: THE CONVERSION FUNCTIONS FOR SCHOOL EDUCATION

**Figure 1: Estimate of conversion function for pre-primary education**

$$q = f(n) = \begin{cases} n & 0 \leq n \leq 15 \\ -1/20n^2 + 5/2n - 45/4 & n > 15 \end{cases}$$

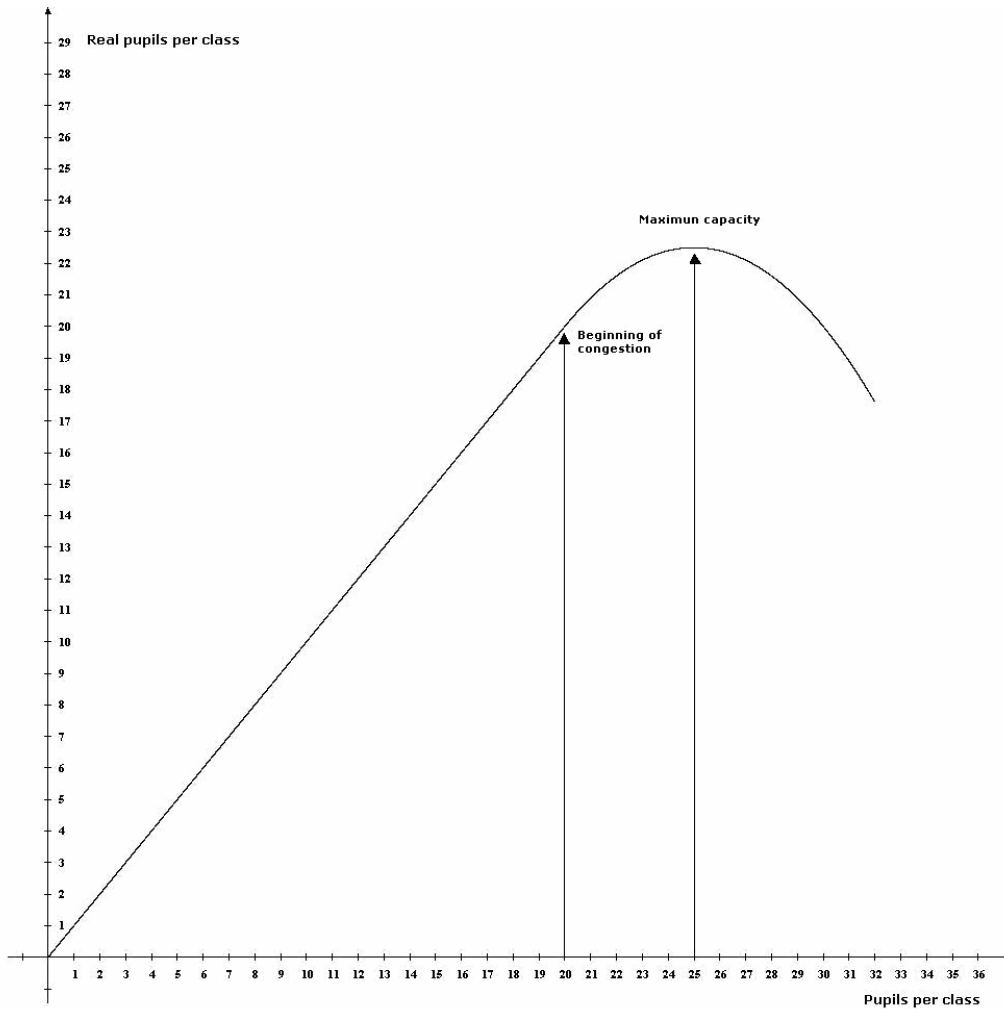
$\max f(n) = f(25)$



**Figure 2: Estimate of conversion function for upper-secondary education**

$$q = f(n) = \begin{cases} n & 0 \leq n \leq 20 \\ -1/10n^2 + 5n - 40 & n > 20 \end{cases}$$

$\max f(n) = f(25)$



## APPENDIX 2

### Faculty and group of homogenous faculties

| FACULTY  | Group                      |
|--|----------------------------|
| 1 Environmental Sciences<br>Natural, Physical and Mathematical Sciences<br>Biotechnology<br>Science and Technology   | Sciences                   |
| 2 Pharmacy   | Pharmacy                   |
| 3 Medicine and Surgery   | Medicine and Surgery       |
| 4 Engineering<br>Aerospace engineering<br>Industrial Chemistry   | Engineering                |
| 5 Architecture<br>Arts and Design  | Architecture               |
| 6 Agriculture  | Agriculture                |
| 7 Veterinary Medicine  | Veterinary Medicine        |
| 8 Sociology  | Sociology                  |
| 9 Political science  | Political science          |
| 10 Law   | Law                        |
| 11 Letters and Philosophy<br>Communication Sciences<br>Library and Archive Studies<br>Philosophy<br>Musicology<br>Humanities   | Letter                     |
| 12 Language and Foreign Literatures<br>Language and Foreign Modern Literatures<br>Italian Language and Culture<br>Modern language for Interpreters and Translators<br>Modern language<br>Islamic studies<br>Oriental Studies | Language                   |
| 13 Cultural Heritage<br>Preservation of the Cultural Heritage  | Cultural Heritage          |
| 14 Psychology<br>Social Sciences   | Psychology                 |
| 15 Economics<br>Banking, Finance and Insurance   | Economics                  |
| 16 Educational Sciences<br>Humanities and Social Sciences  | Education                  |
| 17 Statistics  | Statistics                 |
| 18 Exercise and Sport Science  | Exercise and Sport Science |

### APPENDIX 3: DATA SOURCES FOR UNIVERSITY EDUCATION

To calculate the volume indicator, the average unitary cost indicator, and the quality indicators, the following surveys<sup>18</sup> and databanks, all included in the National Statistics Programme, were used:

1. Survey on University Education carried out by the Statistics Office, Ministry of Education, University and Research, *Enrolled and registered students per academic year*: date of reference 31 July<sup>19</sup>
  - Survey unit: Degree Course (old system), Diploma Course (old system), School aimed at special purposes (old system), Degree Course (new system), Specialised Degree Course (new system), Single Cycle Specialised Degree Course (new system);
  - Variable applied: students enrolled by year of first registration in the university system<sup>20</sup>.
2. Survey on University Education carried out by the Statistics Office, Ministry of Education, University and Research, *Graduates per year*
  - Survey unit: Degree Course (old system), Diploma Course (old system), School aimed at special purposes (old system), Degree Course (new system), Specialised Degree Course (new system), Single Cycle Specialised Degree Course (new system);
  - Variable applied: graduates enrolled by year of first registration in the university system (see note 30).
3. *Database of the degree courses*, Statistics Office, Ministry of Education, University and Research
  - Survey unit: Degree Course (old system), Diploma Course (old system), School aimed at special purposes (old system), Degree Course (new system), Specialised Degree Course (new system), Single Cycle Specialised Degree Course (new system);
  - Variable applied: legal length of the degree course.
4. *Database of professors* (Ordinary Professor, Associated Professor and Researcher), Statistics Office, Ministry of Education, University and Research, date of reference 31 December
  - Survey unit: faculty per athenaeum;

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<sup>18</sup> The production of statistical data on Universities was disseminated by ISTAT until the 1997/98 academic year. Starting from the following year, the surveys and the publication of the results became part of the tasks under the competence of the Ministry of Education, University and Research (MIUR), as established by the ISTAT/MURST agreement, which included the creation, by ISTAT, of the Informative System for Evaluation (SIU), to the purpose of monitoring the university system. The surveys are part of the National Statistical Programme.

<sup>19</sup> Student enrolled in academic year (t-1)/t: student who, on 31 July of the year t, is found to be up to date with all the payments of the enrolment fees, that is to say that he/she has been found to have paid the last instalment. See: Website, Ministry of Education, University and Research, Office III – Statistics Service, *Main applied definitions*.

<sup>20</sup> Ibidem, Year of first registration: academic year in which a student enrolls for the first time in a study course in an Italian university.

- Variables applied: number of the ordinary and associated professors, number of the researcher.

5. *Survey on the final balance statements of university bodies*, Istat: calendar year

- Survey unit: athenaeum.

The following variables from various surveys have been used to apply the model for calculating the *standard cost per student*: students per athenaeum, equivalent professors per athenaeum, costs of production per athenaeum, enrolled students per faculty and per athenaeum, equivalent professors per faculty and athenaeum.

For calculating the quality indicators, on the other hand, the variables are as follows: enrolled students per year of registration per degree course and per faculty; graduates based on the year of first registration per degree course and per faculty, legal length of the degree course.

Since the reference dates of the various surveys are different, the students enrolled in the 2004-2005 academic year, surveyed on 31/07/2005, were used to calculate the volume indicator concerning 2005, the average unitary cost indicator per student for each faculty and the quality indicators.

#### APPENDIX 4: MODEL FOR THE FORMATION OF THE UNITARY COST PER FACULTY

The per capita average cost per enrolled student is calculated for each year.

In order to estimate the unitary cost of each students, by faculty and for each year, a functional correlation was supposed in which the costs of production for education<sup>21</sup> in different universities ( $C_t$ )<sup>22</sup> depend on the number of equivalent professors ( $D_t$ )<sup>23</sup> and on the total number of enrolled students ( $S_t$ ).

The underlying theory is that the overall cost for education in the public university system is:

$$C_t = \beta_{1,t}S_t + \beta_{2,t}DE_t + \varepsilon_t \quad [1]$$

Where:

$t = 2000, \dots, 2005$ , are the years

$C_t = \sum_{i=1}^{62} C_{i,t}$  is the overall cost of production for didactic purposes

$S_t = \sum_{i=1}^{62} S_{i,t}$  is the number of enrolled students

$DE_t = \sum_{i=1}^{62} DE_{i,t}$  is the number of equivalent professors

$i = 1, \dots, 62$  is the number of universities included in S13.

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<sup>21</sup> The “Observatory for the evaluation of the university system” describe a relation between the amount of revenues of each athenaeum (fees paid by enrolled students plus Ordinary Financing Fund (FFO)) and the enrolled students and equivalent professors.

<sup>22</sup> The value of production of each athenaeum for didactic activity was estimated considering the following items: (Expenses for running university bodies + personnel expenses + transfers to departments + financial burdens + tax burdens + expenses for running institutes, centres and clinics + corrective amounts + expenses that cannot be classified in other sections) x 0.48, therefore the overall costs were reduced because it was supposed that the remaining part (52%) was made up of production costs for research (see note n° 28).

<sup>23</sup> The value of equivalent professors for each athenaeum and per athenaeum and faculty  $DE_{i,t}$  ( $i= 1, \dots, 62$ ), was obtained with the following formula:

$$DE_{i,t} = (ORD_{i,t} + 0,72 ASS_{i,t} + 0,47 RIC_{i,t}) \times 0.48$$

In which ORD is the number of ordinary professors, ASS is the number of associated professors and RIC is the number of researchers. Since it was estimated that the working time of equivalent professors devoted to the process of educating university students is equal to 48% of the total time (the remaining time is devoted to research), the value of the DE was reduced by 52%.

For the sake of exhaustiveness the following table shows the regression coefficient for the different years. These calculations have been obtained by using the database referred to the whole set of universities. For the actual index calculation each university has its own production cost, based on its dataset.

**Table 1: Analysis of the results obtained in the different years with the equation [1]**

|  | Years     |           |           |           |           |           |           |
|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|  | 2000      | 2001      | 2002      | 2003      | 2004      | 2005      | 2006      |
| R <sup>2</sup>                         | 0,9884    | 0,9892    | 0,9888    | 0,9864    | 0,9828    | 0,9882    | 0,9846    |
| Production costs<br>(in millions'euro) | 3.640.584 | 3.781.368 | 4.134.547 | 4.336.277 | 4.479.777 | 4.843.758 | 4.989.071 |
| Equivalent professors                  | 16.121    | 16.842    | 17.988    | 18.837    | 18.454    | 19.041    | 19.905    |
| Enrolled students                      | 1.580.978 | 1.569.206 | 1.610.468 | 1.655.324 | 1.704.141 | 1.730.052 | 1.725.740 |

Based on [1], one obtains the average cost per student:

$$C_t / S_t = \beta_{1,t} + \beta_{2,t} DE_t / S_t \quad [2]$$

As one can see, the cost is made up of a constant and of a variable part, related to the number of equivalent professors per student.

The relation [2] can be written for each faculty, then per capita cost for the generic faculty J is equal to:

$$c_{j,t} = \beta_{1,t} + \beta_{2,t} f_{j,t}^* \quad j = 1, \dots, 18 \quad [3]$$

where  $c_{j,t} = C_{j,t} / S_{j,t}$  and  $f_{j,t}^* = DE_{j,t} / S_{j,t}$  is the ratio between equivalent professors and students that is different for each faculty.

In order to define an unitary average cost to attribute to each faculty, it is necessary to estimate the various  $f_{j,t}^*$ .

The  $f_{j,t}^*$  can be determined with a simple regression model; thus, for the faculty j, one will have:

$$c_{j,t} = f_{j,t}^* S_{j,t} \quad [4]$$

Table 2 shows data used as input, while table 3 contains the results obtained.

**Table 2: Total students and equivalent professors per faculty**

| Groups                        | Years             |                       |                   |                       |                   |                       |                   |                       |                   |                       |                   |                       |                   |                       |
|-------------------------------|-------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|
|                               | 2000              |                       | 2001              |                       | 2002              |                       | 2003              |                       | 2004              |                       | 2005              |                       | 2006              |                       |
|                               | Enrolled students | Equivalent professors | Enrolled students | Equivalent professors | Enrolled students | Equivalent professors | Enrolled students | Equivalent professors | Enrolled students | Equivalent professors | Enrolled students | Equivalent professors | Enrolled students | Equivalent professors |
| 01 Sciences                   | 125.259           | 2.914,45              | 124.760           | 3.015,68              | 127.695           | 3.159,97              | 133.360           | 3.279,22              | 139.885           | 3.195,45              | 143.799           | 3.296,91              | 146.618           | 3.368,01              |
| 02 Pharmacy                   | 42.412            | 501,92                | 43.779            | 523,44                | 44.207            | 564,93                | 46.567            | 595,07                | 48.553            | 581,62                | 52.781            | 625,02                | 52.263            | 625,02                |
| 03 Medicine and Surgery       | 97.220            | 3.378,36              | 101.264           | 3.494,03              | 116.412           | 3.773,75              | 123.898           | 3.954,84              | 132.785           | 3.838,57              | 139.872           | 3.823,58              | 147.428           | 3.974,68              |
| 04 Engineering                | 209.534           | 2.380,59              | 211.330           | 2.481,43              | 216.832           | 2.608,62              | 224.309           | 2.643,37              | 229.145           | 2.594,42              | 229.995           | 2.744,60              | 227.909           | 2.802,80              |
| 05 Architecture               | 78.866            | 624,38                | 75.158            | 653,68                | 75.367            | 698,45                | 75.852            | 731,71                | 77.158            | 722,10                | 77.186            | 725,76                | 76.136            | 738,50                |
| 06 Agriculture                | 27.204            | 677,85                | 26.883            | 701,20                | 27.611            | 739,31                | 28.837            | 766,07                | 29.729            | 759,84                | 29.608            | 767,64                | 29.175            | 793,61                |
| 07 Veterinary Medicine        | 13.794            | 287,00                | 13.571            | 303,33                | 13.757            | 326,53                | 14.143            | 343,18                | 14.605            | 332,82                | 14.841            | 337,82                | 14.727            | 359,40                |
| 08 Sociology                  | 22.243            | 69,45                 | 24.777            | 74,31                 | 23.002            | 67,82                 | 14.713            | 75,61                 | 15.186            | 76,48                 | 17.749            | 93,06                 | 16.566            | 98,72                 |
| 09 Political science          | 93.044            | 558,23                | 90.194            | 585,75                | 91.872            | 617,34                | 95.943            | 663,81                | 101.900           | 644,76                | 100.815           | 673,39                | 99.976            | 720,76                |
| 10 Law                        | 265.301           | 846,47                | 252.358           | 901,22                | 241.830           | 977,39                | 234.532           | 1.041,16              | 230.118           | 1.026,90              | 227.507           | 1.071,45              | 221.344           | 1.160,82              |
| 11 Letter                     | 216.385           | 1.848,92              | 212.600           | 1.910,94              | 220.379           | 2.045,57              | 242.890           | 2.129,78              | 247.190           | 2.087,09              | 249.607           | 2.145,51              | 245.100           | 2.268,84              |
| 12 Language                   | 42.716            | 379,06                | 45.475            | 399,61                | 48.939            | 427,65                | 52.120            | 466,84                | 53.859            | 456,74                | 55.796            | 478,89                | 57.089            | 513,81                |
| 13 Cultural Heritage          | 7.201             | 40,38                 | 7.259             | 47,67                 | 7.261             | 57,85                 | 7.396             | 59,79                 | 7.390             | 58,70                 | 6.663             | 59,50                 | 5.905             | 62,05                 |
| 14 Psychology                 | 31.475            | 131,22                | 30.170            | 139,77                | 35.386            | 155,88                | 44.220            | 180,13                | 45.825            | 186,34                | 48.375            | 202,55                | 48.963            | 225,80                |
| 15 Economics                  | 214.706           | 1.055,61              | 206.755           | 1.127,68              | 205.534           | 1.226,10              | 207.555           | 1.312,28              | 210.493           | 1.297,91              | 207.215           | 1.343,14              | 210.237           | 1.443,32              |
| 16 Education                  | 82.970            | 314,21                | 91.576            | 354,74                | 102.301           | 400,52                | 96.624            | 434,86                | 106.464           | 427,07                | 111.138           | 469,90                | 109.288           | 520,87                |
| 17 Statistics                 | 6.622             | 106,78                | 6.146             | 111,56                | 5.366             | 116,05                | 4.746             | 117,74                | 4.316             | 114,14                | 4.000             | 113,69                | 4.000             | 116,41                |
| 18 Exercise and Sport Science | 4.026             | 6,82                  | 5.151             | 15,86                 | 6.717             | 23,93                 | 7.619             | 42,03                 | 9.540             | 52,59                 | 13.105            | 68,84                 | 13.016            | 111,81                |
| <b>Total</b>                  | <b>1.580.978</b>  | <b>16.121,68</b>      | <b>1.569.206</b>  | <b>16.841,90</b>      | <b>1.610.468</b>  | <b>17.987,66</b>      | <b>1.655.324</b>  | <b>18.837,48</b>      | <b>1.704.141</b>  | <b>18.453,54</b>      | <b>1.730.052</b>  | <b>19.041,24</b>      | <b>1.725.740</b>  | <b>19.905,22</b>      |

**Table 3: Results of the different equations applying [4] for each faculty**

| Groups                        | Years          |                  |                |                  |                |                  |                |                  |                |                  |                |                  |                |                  |
|-------------------------------|----------------|------------------|----------------|------------------|----------------|------------------|----------------|------------------|----------------|------------------|----------------|------------------|----------------|------------------|
|                               | 2000           |                  | 2001           |                  | 2002           |                  | 2003           |                  | 2004           |                  | 2005           |                  | 2006           |                  |
|                               | R <sup>2</sup> | f <sub>j</sub> * | R <sup>2</sup> | f <sub>j</sub> * | R <sup>2</sup> | f <sub>j</sub> * | R <sup>2</sup> | f <sub>j</sub> * | R <sup>2</sup> | f <sub>j</sub> * | R <sup>2</sup> | f <sub>j</sub> * | R <sup>2</sup> | f <sub>j</sub> * |
| 01 Sciences                   | 0,9111         | 0,0205           | 0,9190         | 0,0218           | 0,9168         | 0,0224           | 0,9323         | 0,0227           | 0,9239         | 0,0214           | 0,9259         | 0,0213           | 0,9389         | 0,0215           |
| 02 Pharmacy                   | 0,9137         | 0,0107           | 0,8996         | 0,0108           | 0,9184         | 0,0118           | 0,8975         | 0,0115           | 0,8631         | 0,0105           | 0,8469         | 0,0097           | 0,8703         | 0,0105           |
| 03 Medicine and Surgery       | 0,9619         | 0,0348           | 0,9652         | 0,0354           | 0,9348         | 0,0332           | 0,8995         | 0,0330           | 0,9011         | 0,0303           | 0,9186         | 0,0285           | 0,9157         | 0,0278           |
| 04 Engineering                | 0,9749         | 0,0113           | 0,9692         | 0,0116           | 0,9751         | 0,0119           | 0,9474         | 0,0110           | 0,9523         | 0,0107           | 0,9799         | 0,0118           | 0,9556         | 0,0115           |
| 05 Architecture               | 0,9723         | 0,0074           | 0,9736         | 0,0081           | 0,9772         | 0,0086           | 0,9816         | 0,0090           | 0,9723         | 0,0086           | 0,9675         | 0,0086           | 0,9441         | 0,0084           |
| 06 Agriculture                | 0,9229         | 0,0239           | 0,9341         | 0,0253           | 0,9447         | 0,0261           | 0,9467         | 0,0260           | 0,9370         | 0,0251           | 0,9380         | 0,0255           | 0,9372         | 0,0265           |
| 07 Veterinary Medicine        | 0,9490         | 0,0193           | 0,9523         | 0,0207           | 0,9653         | 0,0224           | 0,9790         | 0,0233           | 0,9819         | 0,0222           | 0,9817         | 0,0224           | 0,9843         | 0,0240           |
| 08 Sociology                  | 0,8562         | 0,0023           | 0,8210         | 0,0020           | 0,6305         | 0,0017           | 0,7432         | 0,0040           | 0,7628         | 0,0041           | 0,7829         | 0,0042           | 0,8227         | 0,0051           |
| 09 Political science          | 0,9547         | 0,0057           | 0,9519         | 0,0063           | 0,9473         | 0,0065           | 0,9533         | 0,0068           | 0,9289         | 0,0062           | 0,9637         | 0,0064           | 0,9536         | 0,0069           |
| 10 Law                        | 0,8941         | 0,0028           | 0,8959         | 0,0032           | 0,8948         | 0,0035           | 0,8936         | 0,0039           | 0,8906         | 0,0040           | 0,8869         | 0,0042           | 0,8953         | 0,0047           |
| 11 Letter                     | 0,8994         | 0,0080           | 0,9034         | 0,0085           | 0,9125         | 0,0086           | 0,9155         | 0,0078           | 0,9063         | 0,0073           | 0,9061         | 0,0074           | 0,9161         | 0,0080           |
| 12 Language                   | 0,8101         | 0,0081           | 0,8150         | 0,0082           | 0,8599         | 0,0083           | 0,8677         | 0,0084           | 0,8580         | 0,0079           | 0,8616         | 0,0080           | 0,8804         | 0,0085           |
| 13 Cultural Heritage          | 0,9996         | 0,0056           | 0,9836         | 0,0065           | 0,9898         | 0,0079           | 0,9975         | 0,0080           | 0,9949         | 0,0079           | 0,9843         | 0,0087           | 0,9818         | 0,0103           |
| 14 Psychology                 | 0,9757         | 0,0041           | 0,9685         | 0,0043           | 0,9183         | 0,0042           | 0,8589         | 0,0040           | 0,8845         | 0,0039           | 0,8888         | 0,0040           | 0,8914         | 0,0043           |
| 15 Economics                  | 0,8673         | 0,0046           | 0,8676         | 0,0051           | 0,8635         | 0,0056           | 0,8650         | 0,0058           | 0,8642         | 0,0056           | 0,8865         | 0,0060           | 0,8989         | 0,0063           |
| 16 Education                  | 0,8284         | 0,0033           | 0,8958         | 0,0036           | 0,9173         | 0,0039           | 0,9420         | 0,0044           | 0,9359         | 0,0040           | 0,9273         | 0,0040           | 0,9124         | 0,0046           |
| 17 Statistics                 | 0,9600         | 0,0179           | 0,9515         | 0,0199           | 0,9664         | 0,0235           | 0,9748         | 0,0266           | 0,9717         | 0,0286           | 0,9667         | 0,0307           | 0,9607         | 0,0314           |
| 18 Exercise and Sport Science | 0,3135         | 0,0009           | 0,7491         | 0,0027           | 0,8429         | 0,0035           | 0,8225         | 0,0047           | 0,8253         | 0,0048           | 0,7909         | 0,0052           | 0,6784         | 0,0079           |

Using the relation [3] it is possible to calculate, for the year 2000, the per capita cost for a student enrolled in the generic j faculty,

$$C_j = 162,34 + 205.900,51 \times f_j^*$$

Where for the year 2000

$$162,34 \text{ €} = \beta^1_1$$

$$205.900,51 \text{ €} = \beta^2_1$$

$f_j^*$  is estimated by the relation [4].

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