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The first applications of the metric system in Italy

(1) Introduction

Attempts to standardize the system of weights and measures were carried out in various Italian states at the end of the eighteenth century. Not only did differences exist in the measure systems among the various states, but also within the same state there was a great variety of measures with the same name. The greatest difficulties arose in trading between cities due to the complicated arithmetic operations for the seller, who had to export the goods, and the buyer who had to get his supplies from outside. These reforms, however, were not put into full effect, and it was not until the Napoleonic period, when partial political unification took place in Italy, that a common metric system was introduced. Unfortunately the Restoration brought back fragmentation of the measure system and abolition of the metric system, which was only reintroduced definitively over the whole peninsula after the Unification of Italy. In order to gain an outline of the complex situation in Italy before the introduction of the metric system, one may refer to the conversion tables of the old measures used in each district with the metric system, which the state published after the Unification.[1]

I intend to deal mainly with the north of Italy, above all with those territories which were part of the Cisalpine Republic, which was successively transformed into the Italian Republic and then the Kingdom of Italy, with Napoleon at its head.

(2) The old systems in the north of Italy

Two types of basic linear measures were used: the *braccio mercantile* for materials and the *piede* for land measurements, with their fractions. The units of surface measurement were named *tornatura*, or *pertica*, or *biolca*, or *piò* and had no direct connection with linear measures (they were not equivalent or proportional to the square *piede*), since their origins were more linked to work in the fields. In the Veneto region, for instance, the unit of measure for surfaces was the *campo*, whereas in Milan they used the *pertica*, but the *campo* in Verona was different from that of Rovigo or Padua, the Milanese *pertica* was different from the one used in Cremona, the *biolca* in Ferrara different from that of Modena.

Capacity measures, distinct between dry substances (corn, coal) and for liquids (wine, oil,…) had different names and values: *corba*, *stara*, *sacco*, *moggio*, *rubbio*, for the former, and *corba*, *mastello*, *brenta*, *brento*, *quartaro*, *zerla*, *soglio*, *barile*, for the latter. The *libbra* was generally the basic unit for weight, which could be of two types: the *libbra sottile* (12 *once*) and the *libbra grossa* (18 *once*). Even when the same name was used, the measure differed from town to town, from village to village, even within the same state. For instance, the Bolognese *piede* was not the same as the Milanese, Roman, Mantuan or Ferrarese one etc. The *libbra* was different in every town: in Milan, for example, the twelve ounce *libbra* was worth 0.3268 kg, in Modena 0.3405 kg, in Ferrara 0.3451, in Bologna there were two values: one for trade worth 0.3619 kg, and one for medicine worth 0.3257 kg, and so forth. What is more, the proportion between a measure and its fractions was not upheld, for instance: the *sacco* in Cremona equalled 3 *staja* and 12 *quartari* (106.93 litres or 0.10693 m^3) whereas the *sacco* in Modena was the equivalent of 2 *staja*, 4 *mine* and 16 *quarte* (126.50 litres or 0.12650 m^3) and in Mantua it was 3 *staja* and 12 *quarti* (103.82 litres or 0.10382 m^3). In the same town, one unit of measure could have many variants: *braccio lungo* or *braccio corto*, *braccio da panno* or *braccio da seta*, *braccio mercantile* or *braccio da legname*, …). Besides the basic units of measure, there was also

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[1] For a general outline of the previous situation refer to: Ugo Tucci, "Pesi e misure nella storia delle Società", *Storia d'Italia*, *Volume quinto*, *Documenti* (Torino: Einaudi, 1973), pp. 581–612, and to the relative bibliography.

a great variety of measures for fluids, at times different for wine, oil or oil for fuel, named according to the containers in which they were transported or into which they were poured. For example, in the small town of Comacchio, for wine alone there were eight different measures: *castellata*, *mezza castellata*, *mastello*, *secchio*, *boccale*, *mezzo*, *foglietta*, *terzetto*.

So strong is the tradition concerning units of weights and measures that even today, in some parts of Italy, two terms co-exist in the language, one for the metric system and one for the old form, like the *pertica* or the *campo* in the Veneto region.

(3) Previous attempts at reforms

At various times attempts were made to solve the problem of units of weights and measures within the same state. In Lombardy as far back as 1597 the Spanish governor of the time, Juan Fernandez de Velasco, tried to convert all the measures and weights of all the towns and main villages to the ones used in Milan. The conversion, involving mayors, magistrates and experts, went on until 1604, came up against serious problems and failed as a result. In October 1605, the next governor, De Fuentes, annulled all the decrees of his predecessor, reinstating the old units of measure.

A new attempt at standardisation of weights and measures in Lombardy was initiated in 1772: in 1781 the Milanese *braccio* replaced all the other *bracci* used up to then in Lombardy and its exact length was fixed by Annibale Beccaria who devised a sample divided into *once*, *punti* and *atomi*; however, after various consultations that dragged on until 1783, they were unable to reduce the various *bracci* to the single Milanese *braccio da legname*.

There were two main impediments to the conversion from the old to the new system: firstly, people found it difficult to evaluate the subdivision of the new measures (those who were used to dividing the *braccio* into three, four, or eight parts would have had to use a division in twelve parts to obtain the *once*), and secondly, people had not received enough information about the new system of measures which made them an easy prey to unscrupulous sellers.

A project to convert to a single system of weights and measures was drawn up in the Papal States in the years 1784–86, under Pope Pius VI. The Ferrarese mathematician, Teodoro Bonati (1724–1820), played an important role in gathering information on the weights and measures used in the various areas of the Papal States, comparing them with those used elsewhere, data which were of great use to the Cisalpine Republic, when in 1798, it decided to adopt the metric system.[2]

(4) The situation in Italy after 1797

In 1796 Napoleon's army began its acquisition of part of the Italian territory with the defeat of Piedmont (26th April 1796), the conquest of Milan (16th May 1796) and the capitulation of Mantua (February 1797); there then followed the occupation of Reggio, Modena, Bologna, Ferrara and Ancona, and, on June 29th 1797, the proclamation of the Cisalpine Republic.

While Piedmont was annexed to France at the end of 1798, the territory of Cisalpine Republic absorbed a large part of northern Italy to include Milan, Valtellina, Mantua and Verona, the former dutchy of Modena and Reggio, the former principalities of Massa and Carrara, the former Papal legations of Ferrara, Bologna and Ravenna.

The capital was established in Milan. The government was composed of an Executive Directorate, following the French model. Legislative power was in the hands of the Great Council, divided into two chambers: the Chamber of the Elders (*Seniori*) and the Chamber of the Juniors (*Iuniori*).

Within the Cisalpine Republic there was a great lack of homogeneity regarding the system used for weights, measures and currency which was causing serious impediments for commerce among the various towns, with the result that in the reorganisation of the various administrative sectors of the Republic the problem of weights and measures had to be faced.

Between the end of 1797 and the beginning of 1798 six commissions were set up to deal with the specific aspects of state administration: the Third Commission was responsible for everything connected with the currency, the mint, weights and measures, commerce, arts and crafts, and included the citizens: Savonarola, Borgnoni, Vismara, Biumi, Scarabelli, Cavedoni, and Compagnoni. The first task that the

[2] The results of this research were only partially published: *Diario ferrarese per l'anno MDCCLXXXIX con le notizie del governo presente secolare, ed ecclesiastico della città e ducato* (Ferrara: Pomatelli, 1789).

Commission took on was the problem of introducing a national currency: for this purpose it commissioned an investigation into all the currencies in use in the Republic, studying their intrinsic and nominal value and comparing them to the currency of Milan. It was hoped that the national currency would have a decimal ratio with most foreign currencies, as well as an intrinsic value as near as possible to the nominal value, with a margin of expenditure for the mint which did not exceed three per cent. The Commission was, moreover, responsible for the standardisation of weights and measures in accordance with a metric system, in such a way that weights and measures should correspond to the currency both in nomenclature and diameter, for example that the diameter of the coins should correspond to the decimal fractions of the *oncia* in weight. Shortly after this, on the 21st Ventôse Year VI of the French Republic (11th March 1798) the Great Council deliberated the application of the metric system for the currency, weights and measures for the Cisalpine Republic. The choice was supported through a report (*Rapporto*) by the Commission for Commerce on the new sample of linear measure, drawn up in collaboration with the physicist Giambattista Venturi (1746–1822). The decision to adopt a metric system was, of course, based on the experience of France, and was extended by Napoleon to all areas under French rule.

Then on the 17th Brumaire Year VII (7th November 1798) a law was issued that converted all the measures and weights used in the Republic to those used in Milan, making their application compulsory in all public acts, and reformed the monetary system. In the time necessary for the Executive Directory to put the law into effect the old measures remained operative. In the meantime the International Conference on the metric system was being held in Paris.

(5) The Italian participation at the International Conference on the metric system

It should be remembered that the project to establish a natural unit for measures and weights, which led to the choice of the metre as the basic unit, was initiated by the Academy of Science in Paris during the years from 1784 to 1789, and supported by the proposal presented by Talleyrand at the French National Assembly in 1790. The aim was not only to standardise measures within one state, but also to define a basic linear unit for all measures, of surface, capacity, and weight, that would be universal and reproducible.[3]

The Commission for weights and measures, which also included, among others, Condorcet, Lagrange, Lavoisier, Laplace and Monge, suggested the decimal scale and substituted Talleyrand's initial proposal of adopting the length of the pendulum which strikes the second at the latitude of 45° as a unit of measure, with a fraction of the terrestrial meridian: the ten millionth part of the quadrant of the meridian (1791). Too many variables could, in fact, change the length of the pendulum and, moreover, instead of favouring the 45th parallel, the meridian is the same (at least in a first approximation) all over the Earth.

In reality, the previous measurements of an arc of meridian of a certain width, among which those carried out by Maupertuis and Clairaut in Lapland in 1736–37, and by Bouguer and La Condamine during an expedition to Peru between 1735 and 1744, had produced conflicting results. The new mission, given to Mechain and Delambre in 1792, to calculate the distance from Dunkirk to Barcelona along the meridian of Paris requiring complex geodetic operations, had to be abandoned during the outbreak of war between France and Spain and was taken up again in 1802, but was only brought to a definite conclusion in 1821 (with Biot and Arago).

In the meantime, however, the introduction of a metric system went ahead, a temporary measurement being established for the metre equal to 3 Parisian *pieds* and 11.44 *lignes* (18th Germinal Year III of the Republic = 7th April 1795).[4]

[3] Guillaume Bigourdan, *Le système métrique des poids et mesures: son établissement et sa propagation graduelle* (Paris: Gauthier-Villars, 1901). François Russo, *Eléments de bibliographie de l'histoire des sciences et des techniques* (Paris: Hermann, 1969). *Mètre et système métrique*, edited by Suzanne Débardat and Antonio E. Ten, (Valencia: Artes Graficas Soler, 1993); see in particular: Antonio A. Ten, *L'académie des Sciences et les origines du système métrique décimal*, pp. 15–32.

[4] In 1801 the metre was to be established as 3 Parisian *pieds* and 11.295936 *lignes*, so a Parisian *pied* corresponded to about 32.4839 cm.

The new system catered for the demands of rationalisation and simplicity: all the measures of the same kind were obtained from the main unit, by multiplying or dividing to powers of 10. Among the main reasons which caused the previous attempts at standardisation of weights and measures to fail had been the difficulty in putting the fractions of the new measures into practice.

The Cisalpine Republic was involved, along with other states originating from the French Revolution, in the International Conference on the metric system held in Paris during those crucial years between 1798 and 1799. It was the aim of the conference to involve scientific representatives from other countries in the conclusive phase of the definition of the new measure system by ratifying the decision already taken on the choice of the metre. The conference got underway in the September of 1798. The Italian representatives were Lorenzo Mascheroni (1750–1800) for the Cisalpine Republic, Pietro Franchini (1768–1837) for the Roman Republic, Ambrogio Multedo (1755–1840) for the Ligurian Republic, Prospero Balbo (1762–1837) for the Kingdom of Sardinia, who was later substituted by Anton Maria Vassalli-Eandi (1761–1825) for the Piedmont government, Giovanni Fabbroni (1752–1822) for Tuscany. Other participants included: Van Swiden and Aeneae for the Batavian Republic (Holland), Trallès for the Helvetic Republic, and Ciscar and Pédrayès from the Kingdom of Spain. The foreign delegates present at the conference were eminent scientists, almost all of them teachers of mathematics and physics, but in spite of their qualifications they were not as famous as their French colleagues, such as Borda, Brisson, Coulomb, Darcet, Haüy, Lagrange, Laplace, Lefèvre-Gineau, Méchain and Prony, who were members of the Commission for Weights and Measures.[5]

The collaboration of foreign scientists was not only formal. During the meetings of the conference the instruments used for the geodetic measurements were examined through actual simulations. In January 1799 three subcommittees were set up to examine some particular problems linked to the metric system. The first one, made up of Coulomb, Mascheroni, Mechain, Multedo and Vassalli, had the task of comparing the measures currently used with different samples of the old French measure, the *toise*, with particular regard to variations in temperature; the second one, formed by Bugge (later substituted by Ciscar), Delambre, Laplace, Legendre, Mechain, Trallès and Van Swiden, was given the job of examining and recalculating all the astronomic and geodetic measurements; the third one, composed of Coulomb, Mascheroni, Trallès, Van Swiden and Vassalli was asked to establish the unit of weight. Fabbroni actively collaborated with Lefèvre-Gineau in defining and devising the sample of weight.

The three committees illustrated their conclusions between April 30th and May 30th, and on 17th June the commission presented the final report to the Institute of Science in Paris. On 22nd June the new samples of the metre and kilogram were presented to the *Council of the Elders* and the *Council of Five Hundred*, and so approved by the French scientists and foreign delegates of the respective governments, who were then instructed to promote the diffusion of the new system in their various states.

The international meeting on the metric system was also an occasion for Italian scientists to discuss mathematical questions, not necessarily linked to geodesy, with their French colleagues. Mascheroni, author of the famous *Geometria del compasso* (Pavia, 1797) translated in French in 1798, discussed geometry with Lagrange and Laplace and prolonged his stay in Paris until 1800.[6] Following his involvement in geodetic calculations during the conference, Franchini once more took up spherical geometry and carried out an in-depth investigation which lead to a treatise published in 1805. Multedo submitted, to Lagrange and Laplace, his memoir on combinatorial mathematics, later published in 1809.[7]

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[5] Maurice Crosland, "The Congress on Definite Metric Standards, 1798–99: the First International Scientific Conference?", *Isis* 60 (1969), pp. 226–231.

[6] Jean Dhombres, "Le regard étranger sur la vie scientifique française vers 1800", in: *Métre et systéme métrique*, *op. cit.*, pp. 41–64. See also: Anne Machet, "Mascheroni invité à l'Institut des Sciences", in: *Lorenzo Mascheroni: Scienza e letteratura nell'età dei Lumi*, edited by Matilde Dillon Wanke and Duccio Tongiorngi, (Bergamo University Press, 2004), pp. 33–47; Luigi Pepe, "Lorenzo Mascheroni e i suoi interlocutori scientifici", in: *Lorenzo Mascheroni: Scienza e letteratura cit*., pp. 95–108.

[7] Pietro Franchini, *Trattato analitico di trigonometria e poligonometria rettilinea e sferica* (Lucca: F. Bertini, 1805). Ambrogio Multedo, "Sul calcolo delle quantità hypergeometriche", *Memorie dell'Instituto Ligure*, 1806, pp. 1–65. *Idem*, "Seconda memoria sul calcolo delle quantità hypergeometriche", *Memorie dell'Accademia Imp. delle Scienze e Belle Arti di Genova*, Vol. II, 1809, pp. 230–246. An important contribution to spheroidical trigonometry was given by Barnaba Oriani, the astronomer of Brera Observatory (Milan) who was in correspondance with Laplace, in: "Elementi di trigonometria sferoidica", *Memorie dell'Istituto Nazionale Italiano*,

(6) The Cisalpine Reform

Reform of the system of weights and measures had already begun in the Cisalpine Republic before the works of the International Conference: in the Year VI (1797–98) the Commission for Commerce printed a report on the new samples of linear measure.[8] The aim of the document was to support the decision to impose a new system of measures in the Republic, making improvements in commerce as its justification, since over the centuries the situation in the Republic was such that there existed about twenty or thirty different measures all with the names of either *piede* or *braccio*.

Explanations were given as to why France had abandoned the *pied* as a unit of measure in favour of a fraction of the terrestrial meridian as the basis of linear measures. The choice of the sample for length was based on the fact that it was deduced from nature, in such a way that once established it could not be destroyed or lost. Some mathematicians had tried, in vain, to find, in the combination of geometric entities, some universal constant of length, so the choice of a sample for the measurement of lengths had fallen between the length of the pendulum which strikes the seconds and the fortymillionth part of the meridian. The length of the pendulum presented some problems: its variability, correlated to the force of gravity which was not constant all over the Earth's surface, and time measurement by clocks which also depended on the apparent angular movement of the stars. For these reasons, the sample of linear measures was deduced from the length of the meridian, destined to remain unchanged, and measured with sufficient precision through geometric and astronomic calculations which would be perfected by Delambre and Mechain's measurement of an arc of ten degrees of the meridian from Dunkirk to Barcelona.

However, the metre was found to be much greater than the usual units of length: "a little more than three times the old Parisian *pied*, it increases to about two thirds more than the Milanese *braccio*, and slightly less than two Bolognese *piedi*", thus to indicate the unit of measure it was judged opportune to call it by the most familiar name, i.e *braccio*, which was supposed to correspond to half the metre, making it not too unlike the measures previously in use.

The *Rapporto* was followed by eight Annotations, regarding the Eratosthenes' measurement of the Earth's circumference, the measurements of arcs of meridians carried out in modern times, with descriptions of the required astronomic and geodetic operations, the different measurements obtained, particularly by the Italian scientists (by Beccaria in Piedmont, Boscovich in Romagna, and by the astronomers of Brera Observatory), and the new instruments used in Delambre and Mechain's expedition. Since the measurement of the meridian was not defined according to strict mathematical exactitude and would always involve a certain degree of uncertainty, any possible criticisms were justified by the observation that an error of 8 thousand metres would yield a variation of one ten thousandth part of a Cisalpine *braccio*. The use of the seconds pendulum was not completely put aside; determining the length of a pendulum was simpler and could easily be carried out anywhere, so using the length of the seconds pendulum to work out and verify samples, with a reasonable approximation, was advisable as long as the proportion between the new measure and the length of the pendulum in various places on the Earth was known:

> if […] the pendulum which oscillates for each minute second cannot aspire to being an immediate and exemplary regulator of the new linear measure, it may be used all the same as an indirect regulator or instrument of comparison in order to verify and confirm the measure itself.[9]

According to Venturi, who wrote the technical annotations[10] for the seconds pendulum the ratio between length, i.e. the distance between the point of suspension and the centre of oscillation, and the

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Classe di Fisica e Matematica, Bologna, 1806, 1808, 1810: Vol. I Part I, pp. 118–198, Vol. II Part I, pp. 1–58, Vol. II Part II, pp. 1–58.

[8] *Rapporto della Commissione di Commercio al Gran Consiglio sopra il nuovo campione di misura lineare con annotazioni del cittadino Venturi rappresentante del popolo* (Milano: Tipografia Nazionale, Year VI).

[9] "se […] il pendolo che fa una oscillazione per ciascun minuto secondo non può aspirare all'onore di essere il regolatore ed esemplare immediato della nuova misura lineare, esso per altro servirà utilmente come regola indiretta e come termine di confronto per verificare ed assicurare la misura stessa."

[10] Venturi consulted Teodoro Bonati, and the Modenese mathematician Paolo Cassiani (1743–1806).

Cisalpine *braccio* equalled 1.9804 at the equator, 1.9911 at the Pole, and 1.9862 at the latitude of 45°, which corresponded approximately to the course of the Po River and to the centre of the Cisalpine Republic.

While France abolished not only the old measures but also their old nomenclature, the Cisalpine Republic decided to keep the old names, although with new meaning, in order to favour the conversion to the new system: thus the so-called *braccio cisalpino* was introduced to indicate half a metre, since it was very similar to the to *braccio* already in use in various parts of the Republic, and the terms used for parts of the *braccio* were assigned to its decimal fractions.

For surfaces the unit of measure was to be the *braccio cisalpino quadrato*, which, multiplied by 10.000, was nearly a Roman *iugerum*; for capacity, unlike the French who had decided upon the *litre*, the *braccio cisalpino cubico* was chosen which was quite similar to the *sacco* and the *brenta* used in many towns. For weights there was a conversion table between the different *libbre* in use in the Cisalpine Republic and the French gram, comparing the various weight samples by means of the Magellan balance; definition of the unit of weight was postponed until agreement was reached on what would constitute the easiest to use while still being the best link to the linear unit, the gram, and the decimal progression.

The defeat of the French Army by the Austrians in August 1799 interrupted the process of the reform of weights and measures until the 14th June 1800 when Napoleon won the battle of Marengo. During the period of Austrian dominion (August 1799–June 1800) the practice of a six-monthly verification and official stamping of all local weights and measures was once more put into effect.

It was not until the 15th Pluviôse Year IX (3rd February 1801) that the results of the Commerce Commission were sanctioned by a law, which not only established all the measures of length, surface, volume, capacity and weight, but also set fines for anyone who continued to use the old measures, and, moreover, established the role of inspectors. The government was entrusted with the task of drawing up all the conversion tables with the previous weights and measures used throughout the Republic, and distributing samples to every chief town.[11]

The *braccio* (double the *braccio cisalpino* and, therefore, equal to the metre) became the basic unit of measure for length, its square the unit of measure for surface and its cube the unit of capacity. The *braccio* was divided into ten *once*, one *oncia* into ten *punti* and every *punto* into ten *atomi*. One thousand *braccia* equalled one Cisalpine *miglio*. The measure of surface was also given an intermediate nomenclature: one hundred square *braccia* constituted a *tavola*, ten *tavole* a *pertica*, and ten *pertiche* a *tornatura* (the basic measure for land which, therefore, corresponded to ten thousand square *braccia*); for wood there was a special *braccio legname*, the result of three *braccia* of length times one of width. While the *braccio cubo* remained the measure of volume for solid materials, the measures of capacity differed for liquids and dry substances; for the former the basic measure was the *pinta*, corresponding to an *oncia cubica*, ten pinte made up a *secchio*, ten *secchi* a *brenta*; in its turn the *pinta* was divided into ten *bicchieri*, a *bicchiere* into ten *once*, every *oncia* into ten *denari*; for the latter, instead (e.g. corn) the basic measure was the *mina*, double an *oncia cubica*, ten *mine* equalled a s*taja*, ten *staia* a *sacco*; the *mina* in its turn was divided into ten parts called *coppi*, each further divided into ten *coppelli*. For weights the basic measure was the *denaro*, corresponding to the French gram, ten *denari* were equivalent to one *grosso*, ten *grossi* to one *oncia*, ten *once* to the *libbra*, ten *libbre* to one *peso*, ten *pesi* to one *quintale*; as for the smaller weights every *denaro* was subdivided into ten *grani*, and every *grano* into ten *centesimi*.

On the 24th Fructidor Year IX (11th September 1801) the Minister of Finance announced that the terms of implementation of the aforesaid law had been deferred to a future date still to be defined, as the Government Committee had presented the impediments that prevented completion of the samples for the new measures by the beginning of Year X.

(7) Later reforms

Further simplifications and variants in the names are to be found in the new law on weights and measures (n. 83) issued during the Italian Republic (27th October 1803), following the rearrangement of the territory that Napoleon's Army had conquered: the *braccio* became the *metro*, whose divisions into tens, hundreds and thousands were now named, *palmi, diti, atomi,* respectively. Successive multi-

[11] State Archives of Mantua, *Gridario Romenati*, vol. 117, p. 26.

plication by one hundred transformed the *metro quadrato* into the *tavola* and then into the *tornatura*; the analogous measures of volume were obtained by adding the term *cubo* to the corresponding linear measure; the same measures of capacity were used for dry substances and liquids: the *soma*, a tenth part of the *metro cubo*, divided successively into ten *mine*, one hundred *pinte*, one thousand *coppi*; the units of weight remained the *libbra*, successively subdivided into *once*, *grossi*, *denari*, *grani*, whose multiples became *rubbi*, and *centinaj*.[12]

Great importance was placed on the teaching of decimal calculations and the new system in the primary schools. It was, however, still legal to use the old system for a trial period of three years, after which it was to be abolished and punitive measures introduced for those who transgressed.

As far as the currency was concerned the law of 26th April 1804 set out the definitions of the coinage: there was to be a single national currency throughout the Republic, in the form of the *lira*, with its division in *centesimo*, *mezzo soldo* (worth 2 and ½ *centesimi*, i.e. 0.025 *lire*) and *soldo* (5 *centesimi*, 0.05 *lire*). The three smallest coins were to be in pure copper: the *centesimo* weighed two *denari*, the *mezzo soldo* 5 *denari*, the *soldo* 10 *denari*. Then there were five coins in silver: the *lira* weighing 4 *denari* of silver, the *mezza lira* weighing two, and the *quarto di lira* weighing 1, then the two *lire* coin and the five *lire* coin, weighing 4 and 8 *denari* of silver, respectively. The first real *lira* of the Kingdom of Italy, however, (based on the decimal system 100 *centesimi* = 1 *lira*), was coined by Napoleon in 1808 and corresponded in titre and weight to the French franc (5 grams of silver).

The conversion period was accompanied by the publication of specific manuals and scholastic texts: in 1804 the Government Committee issued an *Istruzione*[13] divided into three parts: the first part contained the rules of the main arithmetical operations on the decimal fractions; the second, the basics of the system of measures in accordance with the law of 1803 for teachers, engineers and surveyors; the third part gave instruction on how to use the tables for the conversion from the old to the new system, and vice versa; in particular, the old Milanese *braccio* was the equivalent of 1.83148 Parisian *pieds* and the metre equalled 1 Milanese *braccio*, 8 *once*, 2 *punti* and ½ *atomo*. The Ferrarese professor Teodoro Bonati, the Bolognese astronomer, Luigi Ciccolini, and Bernardo Manzoni from Carrara worked together on the third part of the government document.

The need to teach young people the new system encouraged the compilers of manuals of arithmetic to devote more space to the metric system in their works; among the works we may recall the text of arithmetic by Francesco Soave and the course of mathematics for the military school of Modena.[14]

Implementation of the new metric system came up against great difficulties and unpopularity, causing considerable delays in controls and stamping of the weights and measures, with consequent need to grant extensions for inspections.[15]

In 1811, The Central Administration office of the Kingdom of Italy one more issued a new law (n. 25)[16] regarding the implementation of the metric system, reconfirming the decree of 1803 and reasserting the compulsoriness of the metric system. The most important innovation in this law was the establishment of the Office for Weights and Measures in Milan, which was responsible for the construction and distribution of the new samples, to the prefectures and communes, the collection of taxes and a two-yearly control of the instruments used for weights, measures, and for the inspectors themselves. Legality of the old measures was, however, recognised, and kept under control until the new ones had been completely assimilated.

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[12] *Bollettino delle leggi della Repubblica Italiana*, from 1st January to 31st December 1803 (Milano: Veladini, Year II), pp. 257–263.

[13] *Istruzione sui pesi e sulle misure che si usano nella Repubblica Cisalpina pubblicata per ordine del Comitato Governativo* (Mantova: Società Tipografica Apollo, 1804).

[14] Francesco Soave, *Elementi d'aritmetica*, part 1 (Milano: Barret, 1807). *Corso di Matematiche ad uso degli Aspiranti alla Scuola d'Artiglieria e Genio di Modena* (Modena: Società Tipografica, 1805). Cfr. Vol. I pp. 166–216: *Breve trattato delle misure e principalmente di quelle del Regno d'Italia* (this part was written by Paolo Cassiani).

[15] See, for example, the "Avviso del Podestà di Mantova" of 20th July 1810 in the State Archives of Mantua: Archivio di Stato di Mantova, *Gridario del Comune*, vol. 39, p. 104.

[16] *Bollettino delle leggi del Regno d'Italia*, part I, from 1st January to 30th June 1811 (Milano: Reale Stamperia), pp. 79–90.

In the first decade of the 19th century, the metric system may be considered to have taken root, with progressive approximations, throughout continental Italy: not only in the Kingdom of Italy which had succeeded the Italian Republic in 1805 with the annexation of the Veneto region, but also in the territories annexed to the French Empire (Piedmont, Liguria, Tuscany, Umbria, and Lazio) as well as in the Kingdom of Naples.[17]

With the Restoration, the metric system was abolished over a large part of Italian territory, remaining in effect only for administration purposes in some cities like Milan.[18]

After the Congress of Vienna (1814–15) the Kingdom of Lombardy-Veneto was formed under Austrian dominion, successively (1859) with the second war of independence Lombardy was annexed to the Kingdom of Sardinia and in 1861 it was proclaimed Kingdom of Italy, but only with the third war of independence did Mantua and Veneto become part of it (1866).

In 1845 the government of the Kingdom of Piedmont and Sardinia issued a special decree to reintroduce the metric system, setting the year 1850 as the final term for its definitive implementation. With the Unification of Italy the metric system (already in effect in Piedmont since 1845) was finally adopted throughout the nation (law n. 132 of July 28th 1861).[19] The nomenclature was that currently in use today (*metro*, *litro*, *grammo*, with multiples and submultiples), except in the case of land measures, for which there was the term *ara*, equivalent to one hundred square metres, now used only for cadastral documents, and the *stero*, which equalled the *metro cubo* and which has now completely disappeared.

Numerous *Conversion Tables* (*Tavole di ragguaglio*) had to be published regarding the various local measures with respect to the metric system, which were to be displayed in shops until 31st December 1870. These *Tavole* provide useful information on the old units of measure in each district, even if the information is not always unequivocal and consistent. An official publication, for the entire territory of the peninsula, was issued in 1877.[20]

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[17] In the Kingdom of Naples a memoir was published by Saverio Scrofani, *Memoria su le misure e i pesi d'Italia, in confronto col sistema metrico francese* (Napoli: nella Stamperia del Monitore delle Due Sicilie, 1812).

[18] See, for example, the second edition of the *Elementi d'aritmetica* by Francesco Soave, *op. cit.* (Milano, 1812), in which tables of old measures were added, or the conversion tables with the Austrian measures published in Mantua: *Tavole di Ragguaglio tra le misure di dimensione peso e valore usate in Mantova … con l'aggiunta dei rapporti generali con .. Regno Lombardo-Veneto, e vice versa* (Mantova, 1827).

[19] *Raccolta delle leggi, dei decreti e delle circolari sul servizio dei pesi e delle misure* (Firenze: Tipografia del Regno d'Italia G. Faziola e C., 1866), pp. 1–44.

[20] *Tavole di Ragguaglio dei pesi e delle misure già in uso nelle varie province del Regno col sistema metrico decimale*. Edizione Ufficiale (Roma: Stamperia Reale, 1877).