

OBSERVATIONS ON CELESTINO GALIANI'S MATHEMATICAL EDUCATION AND SOME OF HIS REFLECTIONS ON THE "LOTTO" GAME*

Luciano Carbone[†] Raffaele Iovine[‡] Nicla Palladino[§]
Guido Trombetti[¶]

*Dedicated to Prof. Liliana Restuccia on the occasion of her 70th
anniversary*

DOI 10.56082/annalsarscimag.2025.3.353

Abstract

Among Celestino Galiani's papers, some handwritten documents concerning Galiani's activity as a consultant to the papal throne have been found, all concerning issues that arose between the end of the seventeenth century and the beginning of the eighteenth century, when the various states began to play a significant role in the management of the lotto game and discussions began regarding its ethical legality and the actual forms of management. The problem was particularly felt in the Papal State and the reflections of Galiani, who had assumed several roles and functions of primary importance within the Church, played an important role in the decisions taken by the papal court. In this paper, we present Galiani's mathematical education and an initial analysis, based on manuscript documents, of Galiani's activity and thought regarding the Lotto game.

* Accepted for publication on November 26, 2025

[†]luciano.carbone1952@gmail.com, Professore emerito Università di Napoli "Federico II", Dipartimento di Matematica e Applicazioni "Renato Caccioppoli"

[‡]raffaeleiovine68@gmail.com, Presidente Pietrasanta ETS Napoli

[§]nicla.palladino@unimol.it, Università degli Studi del Molise, Dipartimento di Medicina e Scienze della salute

[¶]guitrombetti@gmail.com, Professore emerito Università di Napoli "Federico II", Dipartimento di Fisica "Ettore Pancini"

Keywords: Celestino Galiani's mathematical education, Lotto game, combinatorics.

MSC: 01A05, 01A50.

1 Introduction

Celestino Galiani (1681-1753) was one of the most influential Italian thinkers in the field of exact sciences in the first half of the eighteenth century, a period often labelled as pre-Enlightenment. His influence was widely recognized during his lifetime, he was credited with a fundamental role in the spread of Newtonianism and differential calculus and he was not without wide recognition. After his death and the first highly laudatory commemorations, a certain veil covered his memory. The reasons for this partial oblivion are probably various. Certainly, history accelerated a few decades after his death with the French Revolution and the disappearance of the *ancien régime* in which he had worked. Another reason, however, played a fundamental role: Galiani left no published work in the scientific field. He expressed his thoughts in letters, full of general considerations, and in reports on problems for which mathematics and physics offered the appropriate tools for solution. The letters and the reports were reproduced in several copies and had a very wide circulation. It is not unlikely that this choice was due on the one hand to the desire not to draw the attention of the "Congregatio pro Indice Librorum Prohibitorum" of which, as we will mention later, he had experience, and on the other to the desire to highlight the applicative importance of the new conceptions.

We had a rediscovery of Galiani's ideas starting from the end of the Seventies of the Twentieth century.

In this paper we want to examine essentially two issues. The first concerns his mathematical training in light of the numerous researches dedicated to him (See [13]; [17]; [22]; [26]; [27]; [28]; [29]; [30]). To this goal, the story he himself gives in the *Ristretto della sua vita*, preserved at the Società Napoletana di Storia Patria, is also very useful ([23]; [24]). The second concerns one of his reports and the materials connected to it regarding a very sensitive topic as it is related to one of the first non-trivial uses of mathematics in state administration and in the social sciences: the "lotto" game. This is in fact one of the first reports he wrote once he had acquired a complete mastery of the mathematical subject. Among Galiani's papers kept at the Società Napoletana di Storia Patria (also available online on the website www.storiapatrianapoli.it) and the Biblioteca dell'Archiginnasio of

Bologna, we have found some handwritten documents concerning Galiani's activity as a consultant to the papal throne. They are an official opinion entitled *Riflessioni sopra la natura dei lotti e loro giusti valori* (Biblioteca dell'Archiginnasio) and a response to comments made by gaming contractors on behalf of the State, entitled *Metodo et esemplare succinto di tutto il lotto regolato e calcolato per regola di proporzione dal quale chiaramente se ne desume l'avantaggio grandioso di chi si pone a' distinzione del disavantaggio maggiore, che ne risulta dagli altri lotti di Genova, Milano etc.* (Società di storia Patria). We found also two letters from Cardinal Alessandro Albani (1692-1779, [19]) sent in February 1733 to Galiani to have a copy of his writings on the lotto (Società di Storia Patria).

2 Biographical notes on Celestino Galiani

Nicola Simone Agostino Galiani was born in San Giovanni Rotondo in 1681 in an originally wealthy family. His father, after a series of financial setbacks, died in 1688 and he was sent to study in Foggia. At the age of sixteen he wore the habit of the Celestines, a branch of the large Benedictine family founded by Pietro da Morrone (San Celestino V) and took the name Celestino. In 1701 he was sent to Rome as student at the monastery of Sant'Eusebio where in 1707 he became reader first of moral theology and Sacred Scripture, then of dogmatic theology. In 1710 some of his statements were denounced as heretical to the Congregation of the Index. The classic words of Bernard of Clairvaux against Abelard were used against him and his students: "vulpes quae demoliuntur vineam domini" ([7], p.75).¹ The controversy continued until 1713 and ended ambiguously with the direct intervention of Pope Clement XI (born Giovanni Francesco Albani, 1649-1721; [1]). There was a conviction but not an expulsion. The shadow of an adherence to the Jansenist theses remained over Galiani ([25]Nicolini 1951, pp. 30-32; [7]). From that moment, Galiani preferred (or perhaps he was advised not to) publish anything else, limiting himself to distributing letters and reports, even in several copies.

In 1716 he became a lecturer in philosophy at Sant'Eusebio and was appointed, by the Roman Congregation of Water, member of a commission that was to study the possibility of feeding the Reno into the Po. Immediately after he was part of another commission in which there were also representatives of the Grand Duke of Tuscany with the aim of studying the problems relating to the regime of the Chiana and the related Valley. In

¹"The foxes that destroy the Lord's vineyard".

this way, he received the appointment to the chair of Mathematics at the Sapienza University of Rome.

In 1718 Galiani was appointed coadjutor with right of succession to the chair of Church History and Dogmatic Controversies. The following year he also became abbot of the Celestine monastery of Aversa and soon after of Sant'Angelo in Celano. In the following years and up to 1724 he was again involved in commissions, in which imperial representatives were also present, which had to study the problems relating to the eternal issue of the Rhine's flow into the Po.

In 1726 he was assigned an extremely delicate task: to deal on behalf of Emperor Charles VI (then King of Naples) with the centuries-old question of the Legazia Apostolica of Sicily (Sicilian monarchy) which arose with the feudal investiture by the Pope of Roger I the Norman as King of Sicily. It is perhaps worth remembering, to underline the importance of the issue, that the Legazia constituted one of the most important legal bases to justify the passage of the throne of Sicily from the Swabian dynasty to the Angevin dynasty and the consequent condemnation to death of Conradin of Swabia. His interlocutor, in the name and on behalf of Pope Benedict XIII (born Pietro Francesco Orsini, 1649-1730; [8]) was Monsignor Lambertini, the future Pope Benedict XIV (born Prospero Lorenzo Lambertini, 1675-1758; [33]). As expected, the draft agreement was examined by several imperial and papal commissions and was ultimately rejected.

In 1728 Galiani was elected general of the Celestine order for a three-year term. In 1731 he obtained the prestigious designation as Archbishop of Taranto and immediately afterwards the Emperor Charles VI of Habsburg appointed him Major Chaplain of the Kingdom of Naples, a position with numerous functions, including Prefect of the Royal Studies. He retained his position even when Charles III of Bourbon became king of Naples in 1734 and thus he had the opportunity to profoundly reform the university in 1735. From 1737 he served as plenipotentiary at the Roman court for the drafting of a concordat between the Kingdom and the Papacy. The question of the concordat had taken the place of that of the Legazia, but this time the negotiation came to a successful conclusion and the concordat was concluded in 1741, while Lambertini was pontiff. In 1744 he was military bishop when Charles III led the military expedition against the Imperials which led to the victorious battle of Velletri. Twice during Lambertini's papacy, his nomination as cardinal was taken for granted.

Among his many commitments, he founded an academy ([10], pp. 505-506, 508), created a cultural salon and took great care of the education of his two nephews, Ferdinando (1728-1787; [11]) and Berardo (1724-1774; [6]),

both destined for a bright future as scholars and more.

3 Galiani's mathematical education

Celestino Galiani's mathematical education took place between 1701 and 1718. 1701 is the year in which, as Galiani narrates in his *Ristretto della vita di D. Celestino Galiani*, he was sent as a student of Theology to the monastery of Sant'Eusebio in Rome (See [23]; [24]). 1718 is the year in which he refused the chair of Mathematics at Sapienza University of Rome for that of Ecclesiastical History. Reconstructing the framework of Galiani's studies, highly irregular and fragmentary, but characterized by rapid and competent application to the most important scientific themes of the time, means shedding light on a period of primary importance for the history of science. The early eighteenth century saw, in fact, the spread in Italy of new and effective methods of infinitesimal analysis which would characterise from then onwards and up to the present day a good part of the development of mathematics, applied sciences and engineering.

His education appears to be essentially self-taught, through reading original texts. In fact, Galiani owned an impressive library, as his main biographer Nicolini ([25]) informs us. On more difficult questions he engages with highly respected mathematicians, especially through correspondence. Giacinto de Cristofaro (1664? -1725; [9]) almost certainly played a role in his education, at least as far as Cartesian methods are concerned. His relationships with two top-ranking mathematicians are well documented: Guido Grandi (1671-1742; [2]) and Gabriele Manfredi (1681-1756; [31]).

The epistolary correspondence with Guido Grandi has been published in [29].² Celestino Galiani elected Guido Grandi almost as his scientific advisor. In 1714 he was in Rome and wrote that in their correspondence he had the role of the disciple and Grandi that of the maestro. During that period, his scientific knowledge was consolidated. In fact, the letters he sent to the Pisan mathematician always had the careful and detailed tone of real scientific reports. The analysis of Gabriele Manfredi's letters to Galiani³ provides significant insights into his mathematical interests and the debate on infinitesimal calculus, which saw the young Celestino as a close interlocutor with leading European mathematicians. In this regard, it should be

²The originals of Grandi's letters to Galiani are kept at Società Napoletana di Storia Patria in the vol. 30 D 2.; the letters of Galiani to Grandi at Biblioteca Universitaria Pisana.

³They are kept at the Società Napoletana di Storia Patria and edited in [26].

underlined, according to the annotations that Galiani himself makes in the *Ristretto della sua vita* ([23]; [24]), that Manfredi not only had a thorough understanding of Cartesian geometry but also knew the differential calculus which was then almost nascent. Manfredi sent Galiani three letters in which he illustrated the way to conduct the tangent to the Archimedean spiral by using the calculus of infinitely small differences of l'Hôpital. In the second letter of an epistemological nature, Manfredi gave the framework of the criticisms levelled at differential calculus with the aim of undermining and persecuting differential calculus; the third letter concerned the distribution and diffusion of his *De constructione* [21]. All three documents cover a period from 1706 to 1707.

Manfredi was therefore invaluable in helping Galiani learn the new mathematical methods and it was at Manfredi's instigation that Galiani began studying algebra. Algebra will become one of the strong points of his mathematical culture so much so that he planned and partly wrote the unpublished *Tractatus de algebra*⁴; it was divided into six books which also included the treatment of geometric analysis (or analytical geometry, as it is called today) and the method of maximums and minimums.

4 The circumstances of Galiani's intervention on the Lotto

Between the end of the seventeenth century and the beginning of the eighteenth century, the various states began to have a significant role in the management of the Lotto game. Several discussions immediately arose, including the ethical legitimacy of the State and the effective forms of management. The debate was broad and consequently there were numerous economic, statistical and historical studies; the figure of the "player" can be, on the other hand, considered a true literary topos (see [20] and its extensive bibliography).

The problem was particularly felt in the Papal State, due to its particularities and an important role in the decisions taken by the papal court was played by the reflections of Celestino Galiani. Fausto Nicolini ([25], p. 134-135; [34]), in his biographical essay on Galiani, outlines the circumstances. At the beginning of the eighteenth century, the ban on lottery in the Papal State had led to an exodus of players towards cities in other Italian states where it was legal, such as Milan, Turin, Venice, Genoa and Naples. In these

⁴Società Napoletana di Storia Patria Mss XXX D 2, cc 158r-174r.

states, the budgets benefited from this increase in gambling as a part of the sums gambled were collected by the state coffers. Pressed by the requests of the leaders of the Apostolic Camera, Clement XI in 1719 established a congregation to examine the question.

Nicolini ([25]; p.42-43) tells, on the basis of what Galiani himself stated in the *Ristretto della sua vita*, of a meeting between Monsignor Giovanni Maria Lancisi (1654-1720; [32]), Pope's personal doctor, and Galiani. He would have pointed out that an important aspect of the issue consisted in determining a fair reward for the win in relation to the stake and the risk: the fairness of the reward could be established thanks to then recent mathematical calculations. Galiani was then co-opted into the congregation. The episode seems to fit into the more general eighteenth-century debate on the use of probability and statistics in the social sciences and, consequently, in administration (see [14]).

Within the congregation, he found support in Monsignor Lambertini. On this occasion, Galiani had to formalize his opinion in the aforementioned Report. The lottery was permitted, albeit with many precautions. The compromise formula by the commission was the following: the use of such games was not to be permitted in Rome or elsewhere in the Ecclesiastical State except under the conditions and precautions and with the regulations of the congregation. In 1721, under Pope Innocent XIII (born Michelangelo Conti, 1655-1724; [3]), Lotto games were put out to tender throughout the Papal State; probably on this occasion Galiani, consulted again, as confirmed in the first letter of Cardinal Albani of 1733, had to provide the information contained in the *Metodo et esemplare succinto*. Benedict XIII, intent on re-examining the ethical legitimacy of lottery, established a new congregation, of which Galiani was once again a member. This time, Galiani's opinion was in the minority and the pope again banned the game in 1725. Finally, Pope Clement XII (born Lorenzo Corsini, 1652-1740; [5]), after the opinion of a new congregation, readmitted it in 1731. The funds raised through the game were used for the Trevi Fountain and therefore for public works.

The name lotto or lottery game refers to a complex of gambling games that have some common characteristics and numerous variations. It is close, in its structure, to roulette and bingo. The lottery organizer draws a group of numbers (usually five) from a set of numbers (usually ninety). Players bet sums of money on whether certain combinations of numbers will appear within the drawn group of numbers. The organizer can be a private individual (and often a specific state authorization is required) or the State directly. In this second mode the game can be managed directly or outsourced. The two main variants depend on the mechanism of payment of the bet in case

of success. In a first variant, the total amount of money played is calculated; a percentage is deducted from this sum to cover management costs and possibly some specific purpose for which the lottery was announced (mostly charitable). The remaining sum is distributed to the winners according to specific mechanisms, sometimes established in advance and sometimes established once the total amount wagered is known, linked to the a priori probability that the combination chosen by the player will be drawn. In the second variant, the total amount wagered is not taken into account. Bets are settled according to pre-established mechanisms that depend on this a priori probability. In this variant, sometimes much-discussed mechanisms are introduced (the so-called *castelletti*, because they are linked to the registers of bets and their amounts) which limit the disbursement of excessive sums by the organizer; they prevent the house from breaking. In the most common version, prior to the digitalisation processes, the draw took place mostly on a weekly basis, in the presence of an often very large audience. Ninety numbers were each placed into a ball and the balls were placed into a rotating urn. The urn was rotated several times and, immediately after, a blindfolded child extracted five balls in order. The numbers inside the balls were drawn, read out, and displayed to the audience. Galiani is interested in the second variant of the lottery game, managed by the State through contractors.

5 Galiani's works on the Lotto game

The manuscript *Riflessioni sopra la natura dei lotti e loro giusti valori* is made up of 46 pages of approximately 25 lines each. It is the work of a copyist and is written with a certain elegance and clarity. The classic end-of-page references are present. It is divided into an introduction and three chapters. The paper is essentially based on the works of Bernoulli [4], then recently published, Huygens on the game of dice [18] and Frénicle [16] on combinations. However, the calculations appear to be performed completely autonomously. The main effort is directed at making these mathematical developments as clear as possible to those who are either unaware of them or even not very familiar with calculus. To this aim Galiani chooses to use a Euclidean-type descriptive method based on the language of proportions and articulated in propositions and corollaries, to which his interlocutors were accustomed by training. He summarizes the results obtained in final tables. Galiani does not give symbolic formulas, nor the classical definition of probability as the ratio between favorable cases and possible cases and does

not use it explicitly; he prefers to operate empirically drawing inspiration from the methodology already used by Huygens in relation to the dice rolling game.

In the introduction, he states that existing lotteries must be fair, meaning that each player's chances of winning must be proportional to the amount they risk losing. Furthermore, the winnings must be paid with an amount proportionate to the risk of loss. A fair game is commonly understood to be a game that respects the principle of so-called mathematical expectation, that is, it pays the winner a win equal to the stake multiplied by the inverse of the probability of winning. However, Galiani does not go to calculate the mathematical expectation but something closely related. He actually falls within the logic of what he defines as the buying and selling of hopes. It is likely that this point of view seems to him to be the most suitable one to facilitate understanding for people who are not experts on the subject.

Galiani then tries to identify not so much the fair income, that is the mathematical expectation, but rather the fair profit that the player should receive and which he defines as the "fair price". Of course, to obtain the mathematical expectation from a fair profit, the stake must be added and vice versa, to obtain the fair profit from the fair revenue, the stake must be subtracted. Galiani establishes the "fair price" using, for its immediate comprehensibility, the figure of "imaginary players" and begins with an example relating to the dice game. The example is as follows: suppose there are six players; the first bet that the first roll will be a 1; the second that a 2 will be rolled; the third that a 3 will be rolled, and so on until a 6 is rolled. In this case, because all six players have an equal chance of winning and losing, with each player paying the same amount, the game is fair. Then he supposes that only two players are betting by rolling a single dice. The first bets that the first roll will be a 6. The second, however, does not. If the first player bets one shield, the second should bet 5. In fact, the second player can win in five cases and the first player only in one: the probability of the second player winning over the first is as five to one; for the game to be fair, the same proportion must be maintained on the amount wagered.

Then he writes that what he said for a six-sided die is still true for a die with one hundred thousand sides, and what he said about the dice game is true in every other game of pure chance as, for example, if in a container there were one hundred thousand identical and uniform tickets. Galiani continues the treatise by explaining how to obtain the combinations of 90 different numbers. He then gives some rules which today we summarize in the formula $C_{n,k} = \frac{n!}{k!(n-k)!}$: a combination is a selection of n things taken k at a time without repetition. In his specific case, he explains the possible

combinations of the 90 elements taken 2 by 2 for the ambi, 3 by 3 for the terni and so on up to the cinquine. He gets the rule in the following way (recursively): if you want to combine 90 names two by two, you multiply 90 and the number that precedes it, 89. The result must be divided by two: $\frac{90 \cdot 89}{2}$.

If you want to combine 90 names in threes, you multiply the obtained result by the previous number, 88, and divide by three: $\frac{4005 \cdot 88}{3} = 117480$ and so on; the factors in the numerator always decrease by one unit, while the divisors always increase by one unit. Basically he shows that $C_{n,k+1} = C_{n,k+1} \cdot \frac{n-k}{k+1}$.

Subsequently, Galiani gives a first proposition to establish the fair price that players should pay for bets and how much they should receive in case of winning: he demonstrates that whoever bets one scudo on guessing one of the five numbers (out of 90) that are drawn, should receive 17. In fact, he continues, we identify a winning number among the 90 available. Let's suppose that 18 players, each paying just one scudo, each draw five names. Only one player has the identified number and he will receive as a profit the entire sum in play, that is 17 scudi (which is 17 times your bet or 18 times, including the bet itself). Let's imagine the organizer as a player who plays the part of 17 players, that is, by betting 17, he will be able to draw 85 numbers; then it is clear that the player, by betting one, will have to receive 17 (in addition to the one he bet on).

In the lots he examined, however, Galiani found that the winnings were paid not 17, but 14. With a proportion, he then establishes that the right price that the player should have paid is not 100 baiocchi (equivalent to one scudo) but 83.3 baiocchi (in fact, multiplying 83.3 baiocchi by 17 gives approximately 14 scudi).

In modern terms, we consider the classical definition of probability as the ratio between favorable cases and possible cases. The possible cases are the extractions of all the five numbers out of 90, that is $C_{90,5}$. To calculate the favorable cases, it is necessary to consider the fact that the favorable five numbers are those that contain the given number and contain 4 other numbers among the 89 remaining ones, that is $C_{89,4}$. This ratio is just $1/18$ and therefore the mathematical expectation is obtained by multiplying the stake by 18. Galiani similarly calculates the "fair prices", which can be immediately linked to the mathematical expectation, as mentioned, of winning for single numbers drawn, ambis, ternos, quaternas and cinquines without taking into account the costs incurred by the organizers.

One of the conclusions is that in already active lots, the source of injustice often complained about by players consists in the fact that they pay more

for the hope they buy than it is worth. In the second chapter, Galiani redoes the calculations, taking into account the expenses incurred by the organizers, starting from the assumption that a certain percentage of the amount wagered must remain with the organizers precisely to offset the costs of organizing the game. In the third chapter he then discusses the ethical difficulties surrounding the lotto game. The interpretation that the author tends to give about the lottery is therefore a contractual and mercantilist one that brings it closer to commerce. He can then use the opinion of St. Thomas, which he appropriately cites, to deduce that the lotto game cannot be considered intrinsically an evil. In order to consider its introduction into the Papal State legitimate, it is necessary to counter some reservations on specific items. The conclusions he reached were the following: it was not a question of establishing new lotteries; since the people were gambling, it was better to avoid a significant sum of money leaving the Papal State. Furthermore, it was appropriate to make it known to the people that the organizer received a sum of money so as to make it clear to the players how the game worked. People, knowing in advance how much money was being kept by the organizers, could choose to play according to their will.

Celestino's reasoning seems to underestimate what will perhaps prove to be the most delicate aspect of the matter, even for the lottery: the fairly frequent emergence of gambling addiction and its often devastating consequences, a phenomenon well known to the Christian moralists he himself cites for other types of gambling. He can thus use the famous, controversial and much discussed brocard: *scienti et volenti non fit iniuria* (in the form *volenti non fit iniuria* it can be traced back to the Ulpian maxim *nulla iniuria est quae in volentem fiat*, Digesto, libro 47, title 10, section 1,5). Naturally, everything revolves around the term "volenti": the maxim presupposes at least an unconditioned will; but how free is the will of a compulsive gambler?

Almost all states today continue to benefit, and the justifications are those already suggested by Galiani: the lottery, if fair, is not in itself a bad thing; the phenomenon cannot be repressed; the sums received by the state can be used for public purposes. The ban would result in the flight of funds abroad. However, Galiani himself, in the *Ristretto della sua vita*, re-discusses the topic more than twenty years later and seems to decisively retrace his steps, almost to the point of espousing the thesis of a substantial moral illicitness of the lotto game ([24]).

In the Galiani Archive the manuscript *Metodo et esemplare succinto* has the position XXX.A,13 cc. 54r-61v. This is clearly a response to complaints from lottery contractors about their alleged excessive risks. It seems that they base their reasons not so much on the smallness and variability

of the amount of bets over time, but on the possibility of particularly unfavourable events for the organizers, for example concentrating bets on a specific number which will then actually be drawn. The organizers then ask for the introduction of the "castelletto" system, that is, that each possible combination be assigned a winning limit (cfr. [20], p 116). Galiani, then, hypothesizes a rather modest maximum amount for the single extraction and carries out calculations of the same type as those in *Riflessioni*. He comes to rather harsh conclusions against contractors who keep for themselves significant sums compared to the sums wagered by the players. He also notes that a withholding tax of a total of thirty percent of the betting volume by the contractors was foreseen for payments to the state. The amount paid to the State could be used not only for the functioning of the State itself, but also for public utility works. The internal elements of the manuscript suggest that the paper refers to a period in which the game had already been made active, therefore to the pontificate of Innocent XIII.

The two letters from Cardinal Alessandro Albani are dated 7 and 21 February 1733 respectively and have positions XXXI.B.15 cc. 31r-34v. In the first, the cardinal asks Galiani for the opinions he gave Popes Innocent XIII and Benedict XIII on the institution of the lottery game. In the second, he thanks him for sending one of the opinions and declares that he is waiting, as promised, for the second one.

6 Future developments

Regarding Celestino Galiani's mathematical education, further information can be found both in other correspondence and by examining, where possible, the books he owned and any annotations. It should also be explicitly noted that his mathematical education is intertwined with his physical education which sees him, in a tormented way, move from Cartesian to Newtonian conceptions ([15]).

Regarding Galiani's reflections on the lotto game, many questions still remain open. First of all, it is not yet clear how many memoirs and reports Galiani wrote on this topic and how many of these are preserved, not necessarily in his archive. Even Cardinal Albani's letters leave some doubts on this matter. In 1735 Charles III of Naples profoundly reformed the lottery game in his kingdoms ([20], p.14); having become king of Spain, he promoted the birth of the Spanish lottery in 1763 by asking for opinions from Neapolitan experts ([20], p. 26). It seems unlikely that he didn't consult an expert like Galiani, his collaborator. Moreover, the *castelletto* system,

which Galiani disliked, was used.

In Naples around 1740, the total annual betting amount fluctuated around 450000 ducats ([25], p.38). The annual state revenue was therefore approximately 150000 ducats, one of the most important items in terms of consistency in the state budget revenue (see [25], p.32, 132, *passim*). It would be interesting to understand whether these sums were spent on some specific work, among the many attributed to King Charles, such as for example the gigantic *Albergo dei Poveri* or the equally gigantic Vanvitellian palace in Caserta. Again, the prizes set in Rome for lottery winners seemed to be particularly favorable. Almost certainly, actions had to be taken in other Italian states to prevent betting in Rome. Perhaps the letters of Cardinal Albani, appointed protector of the Kingdom of Sardinia by Victor Amadeus II of Savoy, had precisely this aim.

References

- [1] S. Andretta and Clemente XI, *Dizionario Biografico degli Italiani* 26 (1982), *ad vocem*.
- [2] U. Baldini, Grandi and Luigi Guido, *Dizionario Biografico degli Italiani* 58 (2002), *ad vocem*.
- [3] G. Benzoni and Innocenzo XIII, *Dizionario Biografico degli Italiani* 62 (2004), *ad vocem*.
- [4] J. Bernoulli, *Ars Conjectandi*, Typis Thurnisiorum Fratrum, Basileae, 1713.
- [5] A. Caracciolo and Clemente XII, *Dizionario Biografico degli Italiani* 26 (1982), *ad vocem*.
- [6] T. Carrafiello, Galiani and Berardo, *Dizionario Biografico degli Italiani* 51 (1998), *ad vocem*.
- [7] G. Costa, *Celestino Galiani e la Sacra Scrittura. Alle Radici del Pensiero Napoletano del Settecento*, Aracne Editrice, Roma, 2011.
- [8] G. De Caro and Benedetto XIII, *Dizionario Biografico degli Italiani* 8 (1966), *ad vocem*.
- [9] A. De Ferrari, De Cristofaro and Giacinto, *Dizionario Biografico degli Italiani* 33 (1987), *ad vocem*.

- [10] B. De Giovanni, La vita intellettuale a Napoli fra la metà del '600 e la restaurazione del regno, *Storia di Napoli* VI (1970).
- [11] S. De Majo, C. Galiani and Ferdinando, Dizionario Biografico degli Italiani 51 (1998), *ad vocem*.
- [12] E. Di Rienzo and C. Galiani, Dizionario Biografico degli Italiani 51 (1998), *ad vocem*.
- [13] G. Ferraro and F. Palladino, La vita intellettuale a Napoli fra la metà del '600 e la restaurazione del regno, *Archivio Storico per le Province Napoletane* 100 (1992), 153-181.
- [14] V. Ferrone, Il dibattito su probabilità e scienze sociali nel secolo XVIII, *Phys.* 22 (1980), 27-71.
- [15] V. Ferrone, *Scienza, Natura, Religione. Mondo Newtoniano e Cultura Italiana nel Primo Settecento*, Jovene, Napoli, 1982.
- [16] B. Frénicle, Abregé des Combinaisons, *Diverses Ouvrages de Mathématique et de Physique par Messieurs de l'Academie Royale des Sciences [sic]* de l'Imprimerie Royale Paris (MDCXCIII), 45-64.
- [17] R. Gatto, G. Gerla and F. Palladino, Lettere di Giacinto de Cristofaro a Bernard Fontenelle e a Celestino Galiani, *Annali dell'Istituto e Museo di Storia della Scienza di Firenze* 9 (1984), 67-93.
- [18] C. Huygens, De Ratiociniis in Aleae Ludo, in F. Schooten (van) *Exercitationum Mathematicarum Libri Quinque... Quibus accedit Christiani Hugenii Tractatus de Ratiociniis in Aleae Ludo*, Ex Officina Johannis Elsevirii, Lugd. Batav, 1667.
- [19] L. Lewis and Alessandro Albani, Dizionario Biografico degli Italiani 1 (1960), *ad vocem*.
- [20] P. Macry, *Giocare la Vita*, Donzelli Editore, Napoli, 1997.
- [21] G. Manfredi, *De constructione aequationum differentialium primi gradus auctore Gabriele Manfredio*, Typis Constantini Pisarii, Bononiae, 1707.
- [22] S. Mazzone and C.S. Roero, *Jacob Hermann and the Diffusion of the Leibnizian Calculus in Italy*, Olschki, Firenze, 1997.

- [23] M. Natale, Eclettismo teoretico e pragmatico alle origini delle riforme illuministiche. L'autobiografia di Celestino Galiani, *Frontiera d' Europa* 1 (2002), 5-119.
- [24] M. Natale, Ristretto della vita di Don Celestino Galiani. Seconda parte, *Frontiera d' Europa* 2 (2002), 5-78.
- [25] F. Nicolini, *Un grande educatore italiano: Celestino Galiani*, F. Gianini e figli, Napoli, 1951.
- [26] F. Palladino, Tre lettere inedite di Gabriele Manfredi a Celestino Galiani sul calcolo infinitesimale, *Bollettino di Storia delle Scienze Matematiche* 3 (1984), 124-134.
- [27] F. Palladino, Celestino Galiani e i matematici italiani del primo Settecento, *Studi Filosofici* 8-9 (1985-86), 147-160.
- [28] F. Palladino, La formazione scientifico-matematica di Celestino Galiani, *Bollettino del Centro di Studi vichiani* 17-18 (1987-88), 253-262.
- [29] F. Palladino and L. Simonutti, *Celestino Galiani-Guido Grandi. Carteggio (1714-1729)*, Olschki, Firenze, 1989.
- [30] L. Pepe, Il calcolo infinitesimale in Italia agli inizi del secolo XVIII, *Bollettino di Storia delle Scienze Matematiche* 1 (1981), 1-88.
- [31] L. Pepe, Manfredi and Gabriele, Dizionario Biografico degli Italiani 68 (2007), *ad vocem*.
- [32] C. Preti, Lancisi and Giovanni Maria, Dizionario Biografico degli Italiani 63 (2004), *ad vocem*.
- [33] M. Rosa and Benedetto XIV, Dizionario Biografico degli Italiani 8 (1966), *ad vocem*.
- [34] M. Toscano, Nicolini and Fausto, Dizionario Biografico degli Italiani 74 (2013), *ad vocem*.