FERDINANDO GALIANI'S NEWTONIAN SOCIAL MATHEMATICS

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Abstract

The evolution of Ferdinando Galiani's thought toward social mathematic has been neglected by scholars, and his attempt to establish political arguments on the analytical basis remains unexplored. The non-systematic nature of Galiani's intuitions, due to his laziness, largely justifies this underestimation of his scientific program. This paper intends to show that the mature abbé Galiani follows an intellectual itinerary autonomous and parallel to that followed by Marquis de Condorcet in the same years. The anti-Physiocratique querelle represents Galiani's methodological maturation. In contrast with Physiocratic economic doctrine, based on the primacy of deductive methodology, Galiani claims for economic science the realism of circumstance against aprioristic axiomatic hypotheses and rationalist generalizations. Galiani's project, substantially similar to Marquis de Condorcet's approach to social science, can be defined as Newtonian social mathematics opposed to Physiocratic Cartesian social mathematics.

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Ferdinando Galiani's Newtonian Social Mathematics

1. Introduction

This paper examines one of the first attempts, made by Ferdinando Galiani (1728-1787), to apply Newtonian methodology to represent theories and analyze political, social and economic problems, proposing an original approach to social mathematics. This interesting effort, started in the early works, was completed in his maturity, mainly in the *Dialogues sur le commerce des bleds* (1770) and in the political treatise on neutrality (*De' Doveri dei principi neutrali verso i principi guerreggianti e di questi verso i neutrali*, 1782). This evolution of Galiani's thought toward an original form of social mathematics, fully integrated in the Enlightenment intellectual movement, has not been evidenced by the considerable critical literature and his attempt to establish political and economic arguments on an analytical basis remains largely unexplored. In particular, the Neapolitan *abbé* has been considered "rather alien to the spirit of the Enlightenment" (Diaz-Guerci, 1975: xxii), stressing his ambiguous, cynical and Machiavellian nature (Venturi, 1990; Robertson, 2000: 34) and his aptitude for the logic of paradox (typical of the Baroque period) (Ravix, 2018), or highlighting his connection with the philosophy of Giambattista Vico (Nicolini, 1918; Tagliacozzo, 1968; Tiran, 2018; Soliani – Clément, 2018), or emphasizing his eclectic attitude poised between libertinism and Enlightenment (Amodio, 1997). An attempt to frame Galiani's thought in the context of the Enlightenment has recently been made by Koen Stapelbroek, following Vincenzo Ferrone (1995, pp, 220-247), but the outcome is ambiguous, since "in attempting to step outside of the ideological categories of eighteenth century political thought, Galiani also turned himself into an outsider to the Enlightenment" (Stapelbroek, 2008: 224).

The non-systematic nature of Galiani's intuitions, due to his laziness, largely justifies this underestimation of his scientific program. Instead, despite the fragmentariness and the dispersion of his thought, this paper intends to show that Galiani has a coherent and unitary methodological project largely influenced by Newtonianism, which is known to have been an essential component of the Enlightenment debate. The *abbé* Galiani follows an intellectual itinerary, shared by other Newtonians in the same years, asserting the necessity of a general science of society in an intellectual context, the Neapolitan one, in which the application of a rigorous analytical methodology is considered an indispensable tool to understand and describe the complex structure of society, while at the same time highlighting the limits and dangers deriving from the extreme abstraction of social phenomena (see Vico, 1744).

At the beginning of the eighteenth century, the Neapolitan intellectual context was dominated by the so-called *veteres* who opposed the Cartesian philosophy. In particular, Paolo Mattia Doria (1667 - 1746) and Giambattista Vico (1668 - 1744), disapprove of the generalization of Descartes' abstract geometrical method, though they do not reject all forms of mathematical knowledge, and following the Renaissance tradition and Galileo Galilei's legacy, they propose a model of mathematical empiricism in which theoretical laws are determined by induction, not in contrast with empirical observations.

This empirical approach is also incorporated in the Neapolitan Enlightenment movement, initiated by Celestino Galiani (1681-1753), Ferdinando's uncle, and by Bartolemeo Intieri (1678-1757), who remains extraneous to any form of abstract methodology, maintaining close contact with the Galilean heritage (see Galasso, 1989), and proposing a social science rigorously based on empirical foundations. For this research program, Newton's inductive approach, contrasting with Descartes' deductive methodology, offers a new paradigm for scientific analysis compatible with the Galileian tradition. In the Neapolitan intellectual context, therefore, the empirical component of the complex movement of the Enlightenment prevails.

In this perspective, Galiani's exclusion from the Enlightenment intellectual movement have to be reviewed in light of this overlooked methodological approach. In fact, Galiani shares the Enlightenment call for a social science based on a rigorous method, but his approach is strongly realistic and remains immune from abstraction, connecting with the empirical versions of the Enlightenment movement. Galiani's approach manages to combine analytical rigor with the need for empirical evidence, represented, in the field of social science, by historical and institutional contextualization. The interpretation proposed in this paper attributes to Galiani a consistent adherence to Newtonianism as a methodological model in order to construct a conception of social science as a complex discourse that has both a descriptive and normative value.

Galiani's methodological maturation was completed with the anti-physiocratic *querelle*: in contrast with Physiocratic economic doctrine, based on the primacy of deductive methodology, the Neapolitan *abbé* claims for economic science the realism of circumstance against aprioristic axiomatic hypotheses and rationalist generalizations.

The Physiocratic movement is part of the Rationalist strand of the French Enlightenment, strongly influenced by the mediation of Nicolas Malebranche, above all in the ethical view and deistic optimism on the natural order. From the Rationalist tradition, the Physiocratic school derived the idea of an ideal order (*ordre naturel*), which is understood with Reason, defined by general and immutable laws, described by simple arithmetical formulas (*Tableau*) and, finally, used to make resolute political decisions (see Hoselitz, 1968; Perrot, 1992: 369; Cremaschi, 2000: 713-718). Physiocratic economic analysis based on aprioristic assumptions (such as the natural order or the exclusive productivity of agriculture), can be called *Cartesian social mathematics*, inasmuch as “the Cartesian method was consciously and purposely cultivated by the Physiocrats” (Neill, 1948: 168)¹.

¹Pribram uses the term Cartesian economy to define much of the French economic science of the eighteenth century, not limiting this definition only to the Physiocratic school (Pribram, 1983: chap. VII). On the Cartesian influence on the Physiocratic movement see also Bourthoumie (1935); Schuhl (1938); Neill (1948,1949); Hecht (1958); Kubota (1958); Foley (1973, 1976); Mirowski (1991: 154-158); Larrère, (1994); Perru (1997: 620-622); Roncaglia (2005: 96), Diemer – Guillemain (2013: 30-38). On Descartes' influence on the French Enlightenment, see Brockdorff (1937). According to Edgard Allix: “It is Quesnay who transported Cartesianism into social science and he did so through Malebranche”

This dominant Rationalist influence is evident in Physiocratic policy proposals, particularly on the issue of liberalization and deregulation of the grain trade, and Newtonian methodology, based on the experimental approach, remains extraneous to the Physiocratic movement.

In contrast with this vision of social science, Galiani's approach, particularly attentive to the realism of hypotheses, can be named *Newtonian social mathematics* as opposed to the *Cartesian social mathematics* characterizing the Physiocratic school and other rationalist components of the Enlightenment.

The analysis presented will demonstrate a substantial continuity of Galiani's thought between the positions expressed in his early works, under the influence of the Neapolitan Newtonian school, and those adopted in maturity, in the midst of the intellectual controversy triggered by the publication of the *Dialogues*².

This paper is organized as follows: section 2 describes the criticism of Cartesianism and the diffusion of Newtonian methodology in Neapolitan culture, focusing on the epistemological debate on the role of mathematical knowledge; section 3 presents the young Galiani's first attempts to build an economic discourse based on certain, general and constant principles; section 4 describes Galiani's *anti-physiocratic querelle*; section 5 describes the final stage of Galiani's new paradigm for social science focusing on other contemporary Newtonian approaches to social science; section 6 concludes.

2. Neapolitan Mathematical schools and Newtonianism in the Early Eighteenth Century

In the last decade of the seventeenth century in the Kingdom of Naples, as in other regions of Europe, mathematical science was considered an essential part of human knowledge and its

(Allix, 1911: 564). According to Jean-Claude Perrot: "The imprint of Malebranche on Quesnay's thought is clearly identified" (Perrot, 1992: 42).

²Against the critics, Galiani himself claimed the continuity and coherence of his thought (Galiani, 1780: 404; Galiani, 1959: 478).

applications went beyond the narrow field of mathematicians. This interest in mathematics became common among intellectual élites, favoring the general adoption of Descartes' algebraic geometry and the rapid *algebraization* of mathematical language (Garin, 2008: vol. I, chap. 24). In Naples, the Cartesian supremacy was broken in the early eighteenth century, when Paolo Mattia Doria, a nobleman of Genoese extraction who had settled in Naples, and Giambattista Vico, professor of rhetoric at the University of Naples, began to attack Descartes' rational methodology and in particular analytical geometry³. More specifically, Doria, following the Neoplatonic tradition, assigned a central role to the rehabilitation of Euclidean geometry in his controversy with modern mathematical methodology, supporting the merits of the ancient authors versus the moderns. He rejected all developments accomplished in mathematics after Descartes' revolution, and in particular opposed differential calculus, considering it a deviation from the logical foundations of Greek geometry (Doria, 1722-1726; Amodeo, 1924, chap. I; Ferrone, 1995: 525-540; Stapelbroek, 2008).

Despite this opposition to modern mathematics, in the first decade of the eighteenth century, the new tools of differential and infinitesimal calculus were widespread among Italian scholars and were reputed to be useful instruments for much scientific research (Mazzone – Roero, 1997). This diffusion was facilitated by Celestino Galiani's academic reform. Galiani was appointed *Cappellano Maggiore* of the Kingdom of Naples (a sort of Secretary of State for education) in 1732 and immediately started a reform program in order to modernize institutions and to create the conditions for integrating the Neapolitan education system into the intellectual development of the eighteenth century. This project was elaborated under the influence of Newtonian natural philosophy and Lockean rationalism, definitely rejecting the Cartesian epistemological approach. In Naples, as in other parts of Italy, Isaac Newton's scientific program is associated to the great

³“Synthetic [Euclidean] geometry is more certain than and thus preferable to Cartesian geometry. The former proceeds from the indefinite power of known postulates to the unknown. Analytical geometry starts from infinite and descends to minima. Cartesian method is bound to be foundationally uncertain in so far as it assumes a given and then proceeds to divide it into simpler figures until it reaches a minimum element. The product of analytic geometry is certain, but its starting point is not. Synthetic geometry, on the other hand, begins with a starting point that, as made and construed is the image of divine creativity” (Vico, 1710: 27).

heritage of Galileo Galilei's experimentalism and this explains its rapid spread (Casini, 1983; Ferrone, 1995: 129; Bruni – Porta, 2003).

The reform of the mathematics teaching method, based on a Newtonian approach, was an essential element of this project of modernization. Galiani established chairs of mathematics and of theoretical and experimental physics; advanced mathematics was taught also in several religious and military colleges with practical applications, and Celestino Galiani himself was a brilliant mathematician and profound expert of differential calculus (Palladino 1987). The establishment of the *Accademia delle Scienze* (1732), designed to spread rationalist philosophy, completed the modernization of the education system in the Kingdom of Naples (Ferrone, 1995: 201-202). Important support for Galiani's reforms came from the Tuscan Bartolomeo Intieri, a self-educated mathematician, interested in the economic development of the Kingdom (Ferrone, 1995: 43-45; 223-238).

The nascent group of Neapolitan Newtonians (called *novatores*) therefore gave additional support to the fight against the Cartesian school, decreeing its decline once and for all. Newton's inductive approach contrasted with Descartes' deductivistic and aprioristic methodology and offered a new paradigm for scientific analysis (Choen, 1971: 227-251). The Newtonian paradigm provided a solution to the Neapolitan epistemological debate on the role of mathematical knowledge, with the new experimental method embodying the greater realism advocated by Doria and Vico. Moreover, the Neoplatonic deism followed by Newtonians, compatible with Catholic orthodoxy, and a clear distinction between religion and science are two features consistent with a general reaction against Cartesian aprioristic rationalism in early eighteenth century Naples.

Celestino Galiani accepted a particular interpretation of Newton's thought proposed by Dutch Newtonian scientists Willem Jacob 'sGravesande (1688-1742) and Petrus van Musschenbroek (1692-1762) ('sGravesande, 1723, Musschenbroek, 1745). This Newtonian

experimentalism was prevalent within *Accademia delle Scienze* and promoted the shifting of interests from natural to social disciplines, encouraged by Bartolomeo Intieri (Ferrone, 1995: 230)⁴.

The extension of Newtonian methodology favored the application of mathematical tools to social phenomenon, which were considered measureable and could therefore be represented with formal algorithms. Euclidean geometrical nomenclature, with *axioms*, reasonable *postulates* and clear *definitions* in order to present the basic principles, had been used by Vico himself in his *Principles of New Science* (1744), and Euclidean geometry was applied to economic matters by Troiano Spinelli (1712 – 1777) in his works on monetary theory and policy (Spinelli, 1749, Patalano, 2017).

This Neapolitan tradition of geometrical presentation of arguments was easily replaced by new tools of infinitesimal calculus. Celestino Galiani, in his unpublished essay, *Della Scienza Morale* (Ferrone, 1995: 168-176), written probably between 1720 and 1730, makes an initial attempt to define measurable arguments in the ethical doctrine⁵.

This project was mainly based on the philosophical doctrine of pleasure and pain, following the hedonistic doctrine of Locke's *Essay Concerning Human Understanding* (Ferrone, 1995: 173). Pleasure and pain (taken from the second book of Locke's *Essay*) are considered two prime principles of human life and immediately interpreted in terms of mathematical calculus (Galiani, *Della Scienza Morale*, c. 61).

According to Galiani, pleasure and pain are relative concepts, subordinated to quantity and duration and for this reason can be calculated (Galiani, *Della Scienza Morale*, cc. 303r-304v), as Maupertius' *Essay de philosophie morale* (1749), which theorizes, for the first time systematically, the possibility of a mathematical calculus of pleasure and pain. Moreover, in his essay, Galiani not only attempts to apply differential calculus, but also some notions of probability calculus, although he does not achieve any significant results (Ferrone, 1995: 331, footnote 31).

⁴ Intieri's scientific activity was also aimed at practical purposes. He was in fact the inventor of a new method to preserve grain (Intieri, 1754, written with the collaboration of Ferdinando Galiani), and in 1754 promoted the establishment of the first chair in economics, called *Commercio e Meccanica*, entrusted to Antonio Genovesi.

⁵ Manuscript in two versions collected in Società Napoletana di Storia Patria Library (XXI.B.1 e XXXI.C.1).

At the end of the 1740s Newtonian experimentalism was definitely consolidated in Naples (Ferrone, 1995: 248) and started to be applied to social sciences, particularly to economic analysis, called *science of commerce* and already considered an autonomous discipline. Neapolitan Newtonians were interested to establish a close connection between the physical order and social and economic order, establishing a Newtonian approach to social science, which can be regarded as a Newtonian version of social mathematics. This approach to social science was related to the idea of civic progress and to programs of political reforms.

The first attempt in this direction was systematically developed by Ferdinando Galiani, Celestino's nephew, in his well-known treatise on money.

3. *First attempt at Newtonian social mathematics in Galiani's Della Moneta (1751)*

Educated by his uncle Celestino and oriented to social science by Intieri, Ferdinando Galiani in his essay on money provided an early rigorous application of Newtonian methodology to economic matters.

This aim is made explicit in his work:

The laws of commerce correspond with no less exactness to the laws of gravity and the laws of fluids. The desire for gain, or the desire to live happily, is to man what gravity is to physics. Once this is accepted, all the physical laws of matter can be verified perfectly, by one who knows how, in the ethical principles of our lives (Galiani, 1750: 52; Galiani, 1977: 37)⁶.

⁶ The only English translation of *Della Moneta* now available was done by Peter Toscano in 1977 (Galiani, 1977), but it is not accurate and frequently does not capture the true meaning of Galiani's work. In this paper, Toscano's translation will be modified, if necessary, with other existing partial translations (indicated in the text) or with the author's translations.

The young Galiani attempts to build an economic discourse based on certain, general and constant principles represented by laws regulating economic phenomena. Following Newtonian methodology, Galiani proposes an original approach in which the experimental proof of natural science is replaced in social science by an accurate analysis of historical events⁷. According to Galiani, just as the system of planets is built on astronomical observations, made constantly over a long period, thus the investigation of the historical development of society and its institutions provides convincing support for economic laws (Galiani, 1750, *Proemio*).

The first application of Galiani's approach is the definition of the complex law of value⁸. This law, defined as a ratio composed of two other ratios, combines naturalistic elements (*utility* based on physiological needs, and *scarcity* subject to availability of natural resources) with historical and social elements (*utility* can be based on psychological and cultural elements, like *fashion*; scarcity is also based on historical conditions of production). So, Galiani delimits natural law by using historical and social considerations as a limit to abstraction and generalization. In this sense Galiani applies Newton's advice (*Hypotheses non fingo*) that the hypotheses must be close to the facts.

The analysis of price determination follows the same approach. Initially Galiani defines a logical sequence: *value – exchange – price*. The first two steps have an abstract character, they are based on value theory and the general principles governing exchanges; the third step, the definition of the mechanism that determines actual prices, involves an empirical perspective that strongly limits the prediction of hypotheses. For this reason it is very difficult, often impossible, to define the price *a priori*, because scarcity and value depend on consumption, consumption likewise corresponds to, and varies with, value. The problem is therefore made indeterminate, as always

⁷In his first essay on the history of money during the Trojan war, Galiani applies the “historical-philological approach” established by Vico, see Galiani (1963). Vico's philosophy can be defined as a general science of history in which philological reconstruction is the main analytical tool. According to Vico, language is a social construction, and is the foundation of ideas and civil institutions. The history of words and of human institutions coincide, making philology a universal science. The study of philology has the task of interpreting myth, fable, poetry and all the primordial expressions of language as the product of forms of organization of social life (see Vico, 1744”).

⁸ For the debate on Galiani's theory of value, see: Einaudi (1953); Spooner (1956); Lebrun (1962): 329-358; Schumpeter (2006): 286-288; Kauder (1965), Ch. 3; Hutchison (1988), Ch. 15; Giocoli (2001); Patalano (2005).

happens when two quantities which have some relationship between them are set against each other (Galiani, 1977: 34; Galiani, 1750: 47-48).

And “such feats of arithmetic must be what sets the price” (Galiani, 1977: 39; Galiani, 1750: 48), because this achievement requires a perfect knowledge of thousands and thousands of variables that set the final price. Moreover “the calculation of political arithmetic is a risky matter. They are the source of serious errors, for they must all be made without any confirmation or endorsement by the principles; and only principles devoted to such studies could verify such facts and events” (Galiani, 1977: 43; Galiani, 1750: 58).

The calculation of price *a priori* is impossible, but this impotence of human reason is corrected by a providential *Supreme Hand* (or *Providence*) that creates an equilibrium⁹. This tendency to equilibrium derives “not from human prudence and virtue but from the lowest stimuli of all private gain”, transforming selfish instincts into social wealth (Galiani, 1977: 36; Galiani, 1750: 50)¹⁰. This *Supreme Hand* works similarly to Newtonian gravitational theory and the different individual interests, like different bodies in physics, become interdependent and reciprocally influenced, directed toward a harmonious systematic order by an invisible force of attraction (a sort of *moral gravity*). The equilibrium is based upon two principles: first, the initial variations should not be taken into account, but only the permanent and stationary states, since in these last ones the equilibrium is always found, as happens in a vessel, when the water, after the irregular movement, returns to its original level; second, that there is always a moral or physical gravity that prevents extreme movements (see Galiani, 1750: 51-52; Galiani, 1977: 37; see also Cesarano, 1976: 382).

Despite his acceptance of the “hydrostatic analogy” (Waterman, 1988: 94), this equilibrium is not a simple product of natural laws, but is historically determined¹¹. For this reason, the Neapolitan *abbè* Galiani is more interested in the forces that restore the equilibrium than in the

⁹ According to Cesarano (1976, 1999), the concept of natural equilibrium can be taken as the methodological foundation of *Della Moneta*.

¹⁰ The analogy with the Smith’s concept of Invisible Hand is evident, see Paganelli, 2018.

¹¹ The hydrostatic analogy is quite widespread in Eighteenth-Century economic literature. It is lucidly expressed by David Hume in his *Essays* (Hume, 1752: 83-84). See also Cesarano (1976).

static analysis of equilibrium, as is shown by the well-known example of the sudden conversion of a Muslim population that modifies the structure of demand and supply in a certain market (Galiani, 1750: 51; Galiani, 1977: 37). This is an extremely modern program as it is centered on the study of the mechanisms that lead to market equilibrium. Moreover, the adjustment process towards an equilibrium is not conceived as instantaneous or *a-temporal*, but is slow and irregular, always able to cause real effects (Giocoli, 2001: 120). This is the well-known analysis of the ‘augmentation’, or devaluation, of money (Galiani, 1750, Bk. III, ch. 3), in which Galiani claims that the adjustment process triggers the redistributive effects of the transition phase towards post-devaluation equilibrium. In this analysis Galiani outlines a model of behavior in a context of asymmetric information and strategic interdependence, offering an example of empirical observation that delimits theoretical laws¹².

Another example of this “historical experimentalism” is offered by the model of the “tickets” (“bulletini”) presented in Book 2 of *Della Moneta*, in which the abstraction of “analytical method” (Galiani, 1977: 71; Galiani, 1750: 96), used to illustrate the logical nature of money, is immediately reversed in a synthetic approach, closely following Newton’s *31st Query* (Newton, 1730: 80-381), to reveal the actual characteristics of money as it appears in historical reality (“coins are the tickets”) (Galiani, 1977: 70; Galiani, 1750: 94)¹³. In the same way, Galiani rejects rationalist (or Lockean) conjectural history about the conventional origin of money (Galiani, 1977: 48; Galiani, 1750: 66)¹⁴. In Galiani’s methodology “historical experimentalism” (historical and institutional contextualization) thus has the same function as the empirical proof in Newton’s methodology. According to Galiani, the domain of economic laws depends on particular historical

¹² According to Filippo Cesarano, Ferdinando Galiani’s analysis of the effects of an augmentation can be considered a rudimentary version of the rational expectations hypothesis, see Cesarano, 1983: 199-200.

¹³ On Galiani’s monetary theory, see Benetti, 1994; Realfonzo-Patalano, 2001; Costabile, 2016.

¹⁴ How ridiculous are those who claim that men all gathered at one time and agreed to use as money those metals, by themselves useless, thereby endowing them with value. Where are these congresses, the agreements [convenzioni] of all mankind...? [...]. One must indeed say that when all men share in a given sentiment and keep that sentiment for many countries, this is not due to a decision made at a meeting held beside the Tower of Babel or the Ark; it is rather due to the disposition of our souls and to the intrinsic qualities of things, because, these, indeed, are always the same and always will be (quoted and translated in Tagliacozzo, 1968: 98; Galiani, 1977: 48; Galiani, 1750: 66).

and institutional circumstances and cannot be defined in abstract terms, true *sub specie aeternitatis*, but only within the limits of the premises that have been established.

Even if *Della Moneta* is not mathematically formalized, it is evident that many “measurable” concepts are expressed by mathematical logic. It is the case of value law, defined as a ratio composed of two other ratios, or the case of the law of diminishing marginal utility (Einaudi, 1953: 287; Kauder, 1965, Chap.3; for a critical view, see Niehans, 1990: note 4), or the *hedonistic* comparison between alternative pleasures and the consideration of opportunity costs (Galiani, 1977: 21; Galiani, 1750: 28; see Einaudi, 1953: 287). However, the most interesting example of Galiani's mathematical logic is offered by the pioneering analysis of choice under conditions of uncertainty, at the beginning of the chapter on interest, which undoubtedly contains one of the first applications of probability calculus to the economic domain (in terms of the expected value rule).

Over many centuries of ignorance – he argues – men have been so terrorized of chance events and by sheer luck that they have fled from them in fear, as from an untamed, kicking horse from whom they would flee with fright, seeking refuge out of reach. The light of true science has led them, finally, to the discovery that nothing is less fortuitous than chance events. Such events have a constant order and a controlled rule, such that it is possible to find a proportional relationship between the certainty of the present and the uncertainty of the future. Thus, as he quieted his fear, little by little, man began to familiarize himself with the idea of luck, to manage and manipulate it. For the first time, one hears discussions concerning justice in games of pure chance. Though previously scorned, in the hands of Bernoulli, the art of forecasting becomes a branch of mathematics and of truth. From games, men proceeded to more serious matters such as navigation, human longevity, and the harvests of the fields, all for so long the butt of chance. These were measured, valued, and insured, against the wiles of fortune, placing

human prudence in reins and in chains [...] Thus, [thanks] to mathematic[s], many conventions were put straight again, and the justice which the darkness of false science had expelled was recalled. In the face of chance, human daring was calculated and restricted between stable limits (Galiani, 1750: 349-350; Galiani, 1977: 260-261 amended in Giocoli, 2001: 127-128).

Galiani was amongst the first social scientists to realize that the structure of natural sciences, based upon a probabilistic model, is perfectly adaptable to social and economic analysis¹⁵.

Beyond his analytical contribution in this domain, Galiani in this chapter enunciates *de facto* a program of social mathematics. Indeed the Neapolitan *abbé* attempts to find, in the complexity of natural events, a constant order based on provable laws¹⁶. This revealed regularity provides a guide for human actions and constitutes the true social science, opposed to the darkness of false science, not based on calculus and controlled arguments. The mathematical representation of events is extremely useful for practical decisions, as is demonstrated by its application to the art of navigation. The analogy between politics and the art of navigation, as we will see, becomes a central topic in Galiani's thought in his maturity.

4. Galiani's Dialogues: the reaction against Cartesian social mathematics (1770)

The enthusiasm for the ideal model of Newton's science, common in eighteenth-century culture, took on a special meaning in France, acquiring an original feature in its synthesis with the previous Cartesian tradition (Brunet, 1931; Sokal, 1998; Shank, 2008). Although Voltaire, in his *Philosophie de Newton* (1738), stressed the Newtonian empirical approach in contrast with

¹⁵The probabilistic model was also proposed by Georges-Louis Leclerc de Buffon as opposed to the deterministic model of d'Alembert, see Buffon (1777).

¹⁶ "Where there is no certainty or any means of demonstrating it, there is no science" (Galiani, 1977: 22; Galiani, 1750: 28).

Descartes, there remained a considerable legacy of Cartesian deductive methodology in authors like Charles-Louis de Secondat de Montesquieu (1748: 3-4) and Jean Le Rond d'Alembert (1743: II-III) (see Israel – Ingrao, 1990: chap. 1, Oliveira, 2017).

According to d'Alembert, the true model of science, distinct from metaphysics, is based on mathematical and geometrical deductive methodology and every scientific discipline is composed of logical chains, originating in fundamental principles (Cane – Hankins, 1976).

This particular approach, deeply influenced by the Cartesian legacy, which establishes a methodological monism in scientific research, finds a systematic application in the field of economic analysis, with the Physiocratic school¹⁷. For the *Économistes*, economic laws, like natural laws, are immutable, based on simple, constant principles, deducible from the *natural order*. They are the manifestation of the mechanical natural order, based upon the force of human self-interest and readable through the epistemological concept of “evidence” (Quesnay, 1751; see also Luftalla, 1963 and Fischman, 1998). As typical rationalists, the Physiocrats (who called themselves *philosophes économistes*) subscribed to the idea that economic concepts are written in the code of nature and can be read with the aid of reason (Le Mercier, 1767: II: 120-121; 434; Dupont de Nemours, 1768a) as intuitive and evident geometrical concepts. Consequently, economic analysis is an exact science, based on simple, constant principles, subject to invariable rules of natural laws, as indicates the word *Physiocratie* (Du Pont de Nemours, 1768), and subject to rational demonstration like the most certain physical sciences (Le Trosne, 1766: 9; Le Trosne, 1777: 320). Economic science constitutes a *system*, an “ensemble so united by a series of necessary and coherent deductions, that when the chain is broken one can present nothing more than scattered parts, isolated and disordered truths, parts of principles that are as obscure as the language is inexact” (Le

¹⁷In his *Discours préliminaire de l'Encyclopédie* (1751), d'Alembert recognizes that Cartesian mathematization paved the way for the Newtonian climax of the scientific revolution (d'Alembert, 1995: 78-79; Shank, 2008: 16). d'Alembert can be regarded, like Christian Huygens, Gottfried Leibniz, and Johann Bernoulli, as “Cartesian” opponents to the emerging Newtonian methodology. See also Brunet (1931).

Trosne, 1777: I, 492-493, see Neill, 1949: 541)¹⁸. Operating on measurable objects, economic science “is apt to be subject to calculus” (Le Trosne, 1777: I, 320)¹⁹ and the laws of this science are clearly discerned “by reflection, by judgment, by physical and moral arithmetic, by certain calculation” (Dupont de Nemours, 1768: I, III; see Neill, 1949: 543). Mathematical evidence is described by simple arithmetical and mechanical formulae (as *Tableau*) used to make intelligible political decisions (see Hoselitz, 1968; Perrot, 1992: 369)²⁰. Finally, civil and political laws must be dictated by the natural laws and must not interfere with them (*laissez-passer* and free trade)²¹.

In contrast with some recent interpretations, this paper, confirming a consolidated view, considers the Physiocratic movement as part of the Rationalist current of the French Enlightenment, influenced by Nicolas Malebranche²². Although François Quesnay, the recognised founder of the school, followed an eclectic methodological approach (Neill, 1948: 169) and was often called the Newton of new economic science, Newtonian methodology and experimental approach remain extraneous to *philosophes économistes*²³.

¹⁸Although Quesnay did not accept a rationalist treatment of social problems, his disciples considered deductive methodology more appropriate than the inductive approach for economic analysis, because its fundamental principles are by nature quite *evident* and rapidly comprehensible by a series of incontestable logical deductions (Le Mercier, 1767: 194-195; Le Trosne, 1777: I, 492-493; Morellet, 1770: 28-29, see Perrot, 1992: 369).

¹⁹As “Descartes had applied mathematics to philosophy to create modern rationalism [...] in the same way the Physiocrats had applied mathematics to social matters to come out with the exact science of Physiocracy” (Neill, 1949: 543).

²⁰ According to Diemer – Guillemain (2013: 37) the *Tableau* is similar to a machine or a mechanical system in which economic phenomena are reduced to physical phenomena, through a mechanical causality. The *Tableau* “can be seen as a transposition of the principles of Cartesian physics in the field of economic analysis” (Diemer – Guillemain, 2013: 36).

²¹On the evolution of the Physiocratic movement see: Higgs (1897), Shelle (1907), Weulersse (1910), Fox-Genovese (1976), Vaggi (1987) and Vardi (2012).

²²Some recent literature has greatly reduced, if not entirely eliminated, the rationalist Cartesian legacy on Quesnay's School, emphasizing other intellectual influences. This new view considers the sensualist approach predominant in the form of *sensualism normatif* (Steiner, 1992, vol. I: 227-230); or “sentimental empiricism” (Riskin, 2003), or *sensory evidence*, which elevates “Physiocracy to the rank of a science akin to geometry and physics” (Charles, 2004: 465), considering the *Tableau* “a rational recreation” and “a sort of visual calculating machine for wealth” (Charles, 2004: 469). The complex nature of the Physiocratic movement has been confirmed by Liana Vardi, who considers Quesnay's theory of knowledge a “sentimentalisme de la nature”, vacillating “between Cartesian innateness and Lockean sensationalism” (Vardi, 2012: 3). Similarly, for Gianni Vaggi: “Quesnay's methodology is an original mixture of rationalism and empiricism, and he was certainly influenced by authors like Locke and Descartes” (Vaggi, 1987: 20). Vernard Foley also places Newton among the authors who influenced Quesnay's scientific method (Foley, 1973:145). The Newtonian influence on the Physiocratic movement was initially asserted by Mourant (1940). According to Thomas Neill: “in the Physiocrats [there are] mixed, but not integrated, elements of Cartesian rationalism, Lockean empiricism, Newtonian science and deistic optimism” (Neill, 1948: 153). Other commentators on Physiocracy have shown the close similarity between medieval economic thought and Quesnay's school, cf. Beer (1939) or the legacy of natural law, cf. Hasbach (1893).

²³According to Neill: “Except for him, the Physiocrats all subscribed to the deductive method of elucidating detailed laws of economic behaviour from innate principles” (Neill, 1949: 541, see also Neill, 1948: 170).

The mechanical logic of Descartes was adapted to the political project of the Physiocracy, characterizing economic science as a machine of wealth, of which the driving force is constituted by landowners and land rent (Diemer – Guillemin, 2013: 38)²⁴.

Around the time of the Seven Years' War (1756–63), the Physiocracy movement gained great influence in France, winning followers also among rulers in Europe and beyond. Several journals, publications (like the *Encyclopédie*) and political pamphlets appeared, signalling an increasing audience in France and in Europe for the new economic doctrine²⁵. By the early 1760s, the Physiocrats' arguments for liberalization and deregulation of the grain trade had a huge impact in intellectual and court circles, dominating discussions of concrete economic policy issues (Steiner, 1994, Faccarello, 1994). Then, two laws enacted in 1762 and 1764 abolished virtually all restrictions on trade in grain and marked the political success of the school. The years 1769 and 1770 saw a severe subsistence crisis: supplies contracted, prices rose, and grain and bread riots swept large parts of the country. This crisis caused controversy on the implementation of economic liberalization policy, which were judged too abstract and inadequate for the French socioeconomic state.

In this political climate, the most determined attack on the Physiocratic school's methodology and its theories of economic policy was made by Galiani, in his *Dialogues sur le commerce des bleds* (1770)²⁶.

Galiani's opposition to all kinds of hypostatization of concepts and apriorism, already clear in *Della Moneta*²⁷, becomes the central nucleus of *Dialogues sur le commerce des bleds*²⁸. For this

²⁴ According to Karl Pribram, the Rationalist legacy revealed, on the political level, the conservative character of the Physiocratic school: "Cartesian philosophy provided a rallying point for more conservative minds and suggested a well-organized and clearly defined approach to the analysis of physical and social phenomena in terms of universally applicable principles. The Physiocratic doctrine was an outstanding achievement as an attempt to establish a generally valid system of social relationships in accordance with Cartesian philosophy (Pribram, 1983: 103; see also Laval-Reviglio, 1987). "Rejecting Montesquieu's conception, after Quesnay, the Physiocrats defended legal despotism, a position that opened them to criticism in a world that was beginning to tire of full-blooded despotism" (Argemid'Abadal, 2012: 147).

²⁵ On the relations between Neapolitan economic thought and the Physiocratic School, see Villari (1968).

²⁶ About Galiani's anti-Physiocrat *querelle*, see Gaudemet (1899), Galiani (1959), Koch (1961), Tagliacozzo (1968); Kaplan (1979, 2016), Steegmuller (1988), Klotz (2000). Important exponents of French culture intervened against the Physiocrats, see Faccarello (1994).

reason this work by Galiani represents an original methodological perspective, not a belated proposal of 17th century mercantilist policies (like Forbonnais' criticism, see Forbonnais, 1767) and not even an anticipation of 19th century protectionist theories.

According to Giorgio Tagliacozzo, a striking parallelism exists between Vico's attack on Cartesianism and Galiani's polemic against the Physiocrats, the representatives, in the field of economics, of the basic viewpoint of rationalism. As Vico was one of the first and most authoritative critics of Cartesianism, so Galiani was the first and the most forceful critic of abstract economic principles and metaphysical preconceptions (Tagliacozzo, 1968: 109-110). This *Methodenstreit* is clearly expressed by Galiani in his well-known declaration of intents: "I'm for nothing. I'm for people not to reason falsely. The export of common sense is the only one which exasperates me" (Galiani, 1770: 12; translated in Tagliacozzo, 1968: 108). This statement echoes the Newtonian methodological maxim: *Hypotheses non fingo*. Galiani, in his criticism of Physiocracy, contrasts Newton to Descartes, claiming for economic science the realism of circumstance and aims as opposed to axiomatic hypotheses and metaphysical generalizations.

Physiocratic deductive determinism is the methodology of metaphysicians:

Their work is a true mosaic job. It consists of bringing together many small detached pieces, which they must not have made and changed, but that are existent, true, just as nature procures them. From such artistically glued, placed, veiled pieces, a great picture and a new view appears, although entirely made of scattered pieces (Galiani, 1770: 99-100, Author's translation)²⁹.

²⁷"Of the many errors by which our mind is beset and among which it perpetually wanders, very few would be left if it were possible to make people avoid those which stem from relative words taken in an absolute sense" (Galiani, 1750: 179; quoted in Tagliacozzo, 1968: 103).

²⁸ Galiani evidently took Galileo Galilei's *Dialogo sopra i due massimi sistemi del mondo* (1632) as his model, emphasizing the link with the Italian scientific tradition.

²⁹ "General theories and nothing are almost the same thing. The *Économistes* believed that with four rough, vague words and a dozen general arguments they knew everything, and I proved to them that they knew nothing" (Galiani to Madame Epinay, 6 November 1773, Galiani, 1881, vol. II: 274-275; 276; translated partially in Faccarello, 1998: 16).

The thesis on trade liberalization or the main principle that agriculture is the only source of wealth are the result of an abstract determinism in which historical-institutional circumstances and socio-political implications are not even considered. Physiocratic economic principles, not verified by experience, are merely axioms easily refutable by their opponents.

The idea of the supremacy of agriculture is analysed ignoring the fact that agricultural activities are conducted under conditions of uncertainty, under the absolute power of Nature. The farmer is comparable to a gambler, who takes rolls of coins, the price of seeds and labor, to throw them over the field, against the natural elements and the seasons, which hold the stage (Galiani, 1770: 110).

Most economic actions, both by individual agents and governments, take place in a situation of uncertainty, and in this perspective the analysis of circumstances becomes the basic element of decisions. In expressing this opinion, Galiani reaffirms the probabilistic model of science, adapted to social and economic analysis³⁰. According to this complex methodology, the indicators of a suitable policy are not those deduced from abstract axioms, but those that are more useful and coherent to the prudence and wisdom of a particular society.

Therefore, economic policy is reduced to being part of political science, as the art of government, in which the focus is not individual interest, but the more complex context of *raison d'État*, or national interest. This view of economic policy as *art* is confirmed by Galiani through the analogy with the art of navigation (Galiani, 1770: 233-234). The general principle that must regulate the art of government is expressed in the Latin motto “Nil repente!” (nothing suddenly) (Galiani, 1770: 257).

Economic problems – Galiani argues – are complex, because

³⁰ According to Giocoli, in the *Dialogues* Galiani abandons his youthful faith in probability calculus, expressed in *Della Moneta*, for a more complex concept of uncertainty (Giocoli, 2001: 14).

when in a problem there are a lot of variables, the equation becomes indeterminate, or it belongs to the class of problems we call *de maximis et minimis*, and such are in fact all political problems. It is a matter of obtaining the most possible good with the least possible evil. It is an approximation. Nothing in politics can be pushed to extreme limits. There is a point up to which the good is greater than the bad; if you overstep it, the bad prevails over the good (Galiani, 1770: 229; see also Faccarello, 1998: 128).

Galiani's *Dialogues* offers one of the first applications of calculus (or differential calculus) to economic problems in defining a situation of social equilibrium. The notion of *de maximis et minimis*, referring to Gottfried Wilhelm Leibniz's *Nova Methodus pro Maximis et Minimis* (1684), can be applied to every political and economic problem in terms of maximisation/minimization under constraints (Faccarello, 1998: 128). However, mathematical formalization of economic and political problems, even though useful, has a limited domain of application and produces partial results, in the end leaving a degree of indeterminateness. This is a general principle that would be better defined later, in the writings of his maturity.

Galiani himself regarded his attack as a *bombshell* (Galiani to Epinay, 18 November 1769, Galiani. 1959: 350) against the monolithic rationalism of Physiocracy. Galiani's criticisms were rejected with equal vehemence by André Morellet and Pierre Le Mercier de la Rivière (Morellet, 1770; Le Mercier de la Rivière, 1770). In these replies, the Physiocrats systematically defend the supremacy of deductive methodology, rejecting the idea that a theory must be based on solid and verified facts (Morellet, 1770: 28-29) because empirical data are misleading if not connected with a theoretical principle and with natural laws valid everywhere (Morellet, 1770: 35)³¹.

Galiani, forced to return to Naples after ten years in Paris, followed the controversy through his correspondence with French friends Madame d'Epinay, Denis Diderot, Friedrich Melchior von

³¹Criticizing the *Dialogues*, Turgot observed: "He who does not forget that there are political states separated from one another and constituted differently, will never treat well of any question of political economy" (Letter to Madame Lespinasse, 26 January 1770, quoted in Galiani, 1959: 380).

Grimm, and outlined a reply in a satirical form (*La Bagarre*), which remains unpublished (Galiani, 1979)³².

After his return to Naples, Galiani was occupied in political office and in other intellectual interests, far removed from economic analysis. But Galiani occasionally returned to his methodological approach to social science. The correspondence with Madame d'Epinay is an important source in following the evolution of Galiani's thought after the publication of *Dialogues*. In a letter of November 1773, the Neapolitan *abbé* mentions his controversy with Physiocracy, outlining a formal definition of political science.

Politics is the science that promotes the greatest possible good for men with the least possible pain, according to circumstances. This is a solution of the *De Maximis et Minimis* problem. Politics is a curve (a parabola) to delineate. The abscissas will be the good, the ordinates will be the bad. The point will be found where the least possible pain meets the greatest good. This point solves the problem, and these are all human problems, because everything is a mixture of good and bad. You can see that in the beginning all political problems are represented by an indeterminate equation which will be fixed when you apply it to particular cases. Politics is therefore the geometry of curves, the sublime geometry of governments, like the administration (*police*), it is plain and simple geometry: Euclid's six books (Galiani to Madame Epinaï, 6 November 1773, Galiani, 1881, vol. II: 274-275; 276; translated partially in Faccarello, 1998: 16).

In a dissertation dedicated to the economic problem of grain storage in Genoa, Galiani again resumes his attack against Physiocratic Cartesianism, defining its exponents "economists of evidence" (Galiani, 1999: 69), or "true sect of the illuminated" (Galiani, 1959: 436).

³²See also Goodman, 1994: 197-232. Denis Diderot was particularly influenced by Galiani and not only did he oppose the publication of Morellet's essay, but also formulated in the *Apologie de l'abbé Galiani* (unpublished, but written between 1770 and 1771) one of the most violent attacks on Physiocracy, see Diderot (1963) and Davison (1988). On anti-Physiocratic reaction in France, see Orain (2015); in Europe, see Higgs (1897: chap V); Backhaus (2011).

This science that modern Frenchmen out of highest ignorance have called *economic*, when they should have called it *politic*, is much more difficult than it appears. It is reduced to applying very simple general theories to very complicated specific cases. He who believes he knows it through only having understood is a fool, because its theoretical truths are so simple and clear that every child guesses them. It is as if he believes himself a sublime geometer, because he knows that the whole is greater than the parts [...]. But an immense, deep, complex science is required to apply them to a particular country. This science includes ethics, traditions, laws, commerce, agriculture and finance. Every variation makes different cases, and different applications of theories (Galiani, 1999: 69, Author's translation. Italics added).

And finally, in the *Preface* to the second edition of *Della Moneta*, Galiani stresses that thanks to the Physiocrats, economic science “before reaching maturity has come to the corruption of an obscure metaphysical jargon in the mouths of those who France wanted to call economists” (Galiani, 1780: [3], Author's translation).

5. The final point of arrival of Galiani's methodological path and other contemporary Newtonian approaches to social science (1782)

When the anti-Physiocratic controversy was closed, another occasion to reiterate his approach to social mathematics was offered in the treatise *De' Doveri De' Principi Neutrali verso i Principi Guereggianti, e di questi verso i Neutrali*, published in 1782 and written to justify the Neapolitan adhesion to the League of Armed Neutrality, led by Catherine the Great. In this case Galiani's arguments become more systematic (Stapelbroek, 2011). According to the Neapolitan *abbé*, to avoid mistakes and uncertainties, the science of law must be represented geometrically, that is rigorously, by axioms and first principles, from which it is possible to infer all truths and

solutions, as in geometry, in which innumerable truths originate in a few definitions (Galiani, 1782: XI-XII). The moral sciences can acquire geometrical rigor in the clarity of expressions and proofs, because their object, like geometry, consists of comparable relations of quantities, which can be expressed by means of calculus. (Galiani, 1782: 16, footnote; 20, footnote).

In conformity with the geometrical method, Galiani, at the beginning of his treatise, defines the limits of matter, using primitive definitions and axioms, self-evident and true, as the basis of every other statement (Galiani, 1782: 6-13). Beyond specific analysis of the political neutrality problem, in this treatise Galiani offers several elements of his idea of social mathematics. The starting point is human nature. Man is divided between two forces: an instinct of conservation (self-interest) and the need for relations with other men, whether conflicting or friendly.

Every moral question is not a simple search amounting to how, in a given case, one can do the greatest good for oneself, or how one can give the greatest benefit to other men; but it is a composite problem always amounting to how, in a given case, one can obtain the greatest good for oneself at the cost of the smallest possible injury to others, or again how one can obtain the greatest good for other men at the cost of the least trouble to oneself. These are the problems that geometers call *De Maximis et Minimis*, theories of which are adaptable, so perfectly, to the study of morals (Galiani, 1782, pp. 16-18; see also Faccarello, 1998: 16)³³.

In a footnote to the text, Galiani drafts an example of geometrical formalization, using a coordinate system, in which the two contrasting human forces give rise to a circular curve, whose tangent represents the perfection of virtues (Galiani, 1782: 18, footnote 1)³⁴. In another passage of

³³ In a note added to the second edition of *Della Moneta* (1780), Galiani claims his attempt to define a general equation for justice in contract, based on the principle that “whatever makes the reason for comforts vary, relative to us, should also cause to vary an equal sum of things such as must be given in exchange for the first thing” (Galiani, 1977: 319, Note 34; Galiani, 1780: 415).

³⁴ Another example of Galiani's way of reasoning is offered by his correspondence: he writes: “If we create a calculated geometry, we find the good = x, the evil = y, and the equation will be: + x - x = 0; + y - y = 0” (Letter to d’Epinay, 26 April 1777, Galiani, 1881, vol. II: 504).

his work, Galiani defines the human will as “a hyperbole between its asymptotes, freedom and coercion” (Galiani, 1782: 412, my translation).

In this attempt at formalization, Galiani follows Leibniz’s argument on the relation between geometrical quantities and the shape of a curve, and Newtonian terminology (explicitly using the term *fluent*; Galiani, 1782: 267), but he ignores the concept of functional relation, as the expression of the relationship between variables by means of *equations*, outlined in Eulero’s classic *Introductio in Analys in Infinitorum* of 1748 (Eulero, 1748). Galiani’s method is completely influenced by the concept of calculus developed by Newton and Leibniz and strictly linked to 17th-century analysis. In fact the principal object of study in 17th-century mathematics was the analysis of geometric curves, formulated in different methods for solving problems regarding curves, tangents to curves, areas under curves, lengths of curves, and velocities of points moving along curves (Kleiner, 1989).

Galiani’s attempt is not isolated in the complex context of the European Enlightenment and it is useful to make a brief comparison with other contemporary Newtonian approaches.

The reaction against an imprudent use of mathematical notation in economic analysis is the nucleus of Condorcet’s *Tableau général de la science qui a pour objet l’application du calcul aux sciences politiques et morales* (Condorcet, 1793), which can be considered the social mathematics *Manifesto* (Ingrao-Israel, 1990; Feldman, 2005). Condorcet distinguishes this science from Petty’s “Political Arithmetic” and Buffon’s “Moral Arithmetic” (Condorcet, 1793: 93-94), limiting the application of calculus to moral and political sciences³⁵. Using the French word *calcul*, Condorcet refers, above all, to calculus of probabilities as the main instrument for the development of the social sciences (Williams, 1994: 104). The application of mathematical logic to social science requires a methodological elaboration to avoid abstract and naïve algebraic formalization. In the *Tableau*, Condorcet outlines a complex structure of new social mathematics, based on five preliminary theories: probability theory; theory of quantity (which includes the theory of money

³⁵ What Condorcet meant by “Mathématique Sociale” has been studied by several authors: see, in particular, Laboulle (1939), Granger (1956), Baker (1975), Williams (2004), Crépel and Gilain (1989), Perrot (1992): 357-376; Crépel and Rieucan (2005), Rothschild (2001) and (2005), Monjardet (2008).

interest), theory of combination (algebraic basis for the calculus of probabilities), deductive theory (the method for deducing from observed facts either general facts or even more general laws) and the theory of mean values (Condorcet, 1793: 97). Among these preliminary theories, Condorcet does not mention differential and integral calculus, because he does not believe that they could be systematically applied to the political and moral sciences (Crépel and Rieucan, 2005: 255).

Condorcet's reaction against an extended use of mathematical language follows the polemical arguments used by Georges-Louis Leclerc de Buffon and Denis Diderot against the mathematical radicalism advocated by D'Alembert (see Buffon, 1749: *Premiere Discourse*; Diderot, 1761; see also Krakeur – Krueger, 1941; Casini, 1988; Richards, 2006).

Condorcet is interested in the distinction between mathematics and economic analysis, underlining that “these two sciences must not be confused” (Condorcet, 1793: 109-110). Political economy provides theory and observation of facts, without calculus, while social mathematics offers solutions based on calculus, allowing policy makers to calculate the effects of the measures adopted. Social mathematics is only a tool and involves facts and ideas only as a foundation for the calculus of the solid basis (Laboulle, 1939: 53; Crépel and Rieucan, 2005: 266). Condorcet's approach preserves the Newtonian methodological paradigm, based on observation of facts and on a limited application of mathematical tools.

Despite the differences, Galiani and Condorcet attempt to delineate a Newtonian solution to the epistemological debate on the role of mathematical knowledge in the social sciences, but this approach did not develop further³⁶.

In Scottish moral philosophy, Francis Hutcheson re-proposed the analogy between egoistic motives and the functioning of gravity in the physical laws, applying mathematical concepts to his analysis, arriving at a rigorous formulation of the utilitarian principle (Hutcheson, 1725; Brooks-Aalto, 1981; Pribram, 1983: 121). However, Hutcheson's position remained isolated because

³⁶ Condorcet, unlike the Neapolitan *abbé*, defended liberalization measures (see Condorcet, 1774). On the relation between Condorcet and the Physiocratic School, see Perrot (1992): 358-376.

neither David Hume nor Adam Smith made attempts to apply mathematical concepts to social science, proposing a skeptical Newtonianism³⁷. According to Hume, mathematics is not a useful tool in the field of moral philosophy and all attempts to extend this instrument beyond the bounds of abstract science “are mere sophistry and illusion” (Hume, 1748: 252, see also Demeter, 2014: 171-180). Even Smith, while proposing abstract concepts and generalizations, does not use mathematical formalizations showing a diffidence towards symbols and long chains of reasoning (Redman, 1997: 215-218).

During the decade of the French revolution, economic analysis reacquired an abstract character and was defined in terms of formalized axioms, with empirical analysis being confined to an auxiliary role, neglecting Condorcet’s methodological line. This approach, mainly due to the ideologues of the *Classe des Sciences Morales et Politiques* at the *Institut de France*, is deeply influenced by the Cartesian legacy³⁸. An example is Nicolas-François Canard, who won the Institut de France prize with his essay (subsequently published in book form) *Principes d’économie politique*, proposing an effective merger between algebraic formalization and the economic concepts embodied in Adam Smith’s work³⁹.

In Italy, Antonio Genovesi (1713-1769), at the end of the 1740s, started his collaboration with Intieri and Celestino Galiani, showing growing interest in social science, and particularly in the new economic discipline. But the role of Genovesi, the first holder (since 1754) of a chair in political economy (called *Commercio e Meccanica*)⁴⁰, was ambiguous: his conception of *economia civile* (civil economy, Genovesi, 1765, 1767, see Porta, 2018) privileged an ethical and political perspective, completely neglecting the methodological connection between economics and

³⁷ For the concept of sceptical Newtonianism applied to Smith, see Cremaschi, 1989. Foley (1976; chs. 2,7,9) considers Smith’s methodology largely influenced by the Cartesian philosophy rather than by Newton. See also Cremaschi, 1981: 129. For common intellectual frameworks between Scottish and Neapolitan Enlightenment, see Robertson, 1997.

³⁸ On the ideologue school, see Kaiser (1980), Quantin (1987).

³⁹ On Canard’s thought see Theocharis (1983), pp. 69-83; Tortajada (1990), Perrot (1992): 35.

⁴⁰ “The Neapolitan Chair, the first to be created in the world, was entitled, to start with, *Commercio e meccanica*, i.e., Trade (or Commerce) and Mechanics, thus emphasising the broad scientific perspective of establishing a bridge from Newtonian Mechanics to what would a little later be called *Economia civile*” (Porta, 2018: 535). See also Roncaglia, 2005: 109.

mathematical tools, drawing criticism from Pietro Verri for the lack of scientific rigor (Verri, 1766; 32; Ferrone, 1995: 260)⁴¹. Nevertheless, Genovesi was still interested in the Newtonian approach in the field of moral philosophy: in the *Diceosina* (Genovesi, 1766) he proposed an ethical system based on Newton's *Principia*, establishing a connection between the law of gravitation and human behavior. Genovesi's underestimation of social mathematics in favor of the primacy of the political and ethical dimension in economic analysis, brought to a close the program of research started by Celestino Galiani's circle.

6. Concluding remarks

Newton's approach offers a new paradigm for scientific analysis, opposing mathematical empiricism to Cartesian mathematical metaphysics (Choen, 1971: 227-251). In this approach, mathematical knowledge, although necessary for analytical rigor, is never complete and since there is a part of reality that escapes it, the application of mathematical tools is limited to measurable concepts. Theoretical laws, elaborated in algebraic forms, must not contradict the empirical observations.

Under the influence of the Newtonian approach to scientific analysis, Galiani proposes a new paradigm for economic methodology which can be called *Newtonian social mathematics*. Despite the absence of systematic reasoning, Galiani's approach is an original contribution to the emerging connection between the evolution of economic knowledge and the rise of the scientific method. While supporting the need to establish a social science on certain principles and general laws based on the utilitarian approach (defined by the principle: "the greatest good for oneself at the cost of the smallest possible injury to others" (Galiani, 1782, pp. 16-18, see also Faccarello, 1998:

⁴¹ Lombard authors showed a greater attraction for the Cartesian model of social mathematics, falling into a naïve application of mathematical formalization to economic reasoning. This is particularly evident in the sixth edition of Pietro Verri's *Reflections on Political Economy*, published in 1772, including some footnotes, attributed to the Milanese mathematician Paolo Frisi (1728 - 1784), in which an effort is made to translate economic arguments into mathematical equations (Bianchini, 2002; Tubaro, 2002). This attempt at formalization increased the opposition to applying mathematical tools to economic reasoning and Verri eliminated Frisi's notes in the following edition of his *Reflections*.

16), Galiani rejects a mechanistic application of deductive methodology to the social and economic system, drawing an appropriate epistemic distinction between natural science and the social and political sciences. In line with Newtonian mathematical empiricism, Galiani proposes a limited mathematical formalization of economic laws, claiming the supremacy of historical and institutional contextualization over abstract theory (Einaudi, 1953: 281-282; Tagliacozzo, 1968: 109-110; Demaria, 1972: 675)⁴². Galiani's Newtonian social mathematics proposes a synthesis between general and abstract aspects of an economic phenomenon and the particular historical characteristics which this phenomenon assumes in different historical contexts. Moreover, rejecting the deterministic approach, the Neapolitan *abbé* elaborates a probabilistic model, in a condition of uncertainty (an analogy with the art of navigation), highlighting the interdependence of individual choices and analysis of behavior in a strategic context (Demaria, 1972: 630)⁴³.

In the field of economic analysis, Galiani, as a conscious follower of the Newtonian methodological lesson, proposes arguments based on real contents inserted in the historical context and rejects the apodictic truths of deductive methodology. According to this complex method, the appropriate measures of policy are not those resulting from abstract axioms, but those that are more useful and more consistent with prudence and common sense. Galiani proposes a gradualist approach to policymaking, rejecting the “shock therapy” proposed by the Physiocratic school and defining a conception of economic policy as a general art of government, and as a component of political science⁴⁴.

⁴²According to Luigi Einaudi: “Galiani is dominated by historicist spirit [...], because he is a true scientist, who knows the limits of abstract reasoning and knows that, if economic laws are within the limits of the premises, true *sub specie aeternitatis*, their validity cannot be extended beyond the field delimited by the premises” (Einaudi, 1953: 281-282). Einaudi considers Galiani a precursor of the German Historical School (Einaudi, 1953: 271).

⁴³This idea derives from Newtonian gravitational laws, according to which every element, in nature, influences each other (Giocoli, 2001: 121).

⁴⁴According to Filippo Cesarano (Cesarano, 1999: xxxiii), Galiani's approach to economic policy anticipates the theory of Avinash Dixit (1996) who introduces a political dimension to the analysis. See also Cesarano (1986, 1995).

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