

# Augustin Cournot: Modelling Economics

**Cournot Centre for Economic Studies**

**(formerly the Saint-Gobain Centre for Economic Studies)**

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# Augustin Cournot: Modelling Economics

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*Edited by*

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France*

THE COURNOT CENTRE FOR ECONOMIC STUDIES SERIES

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**Jean-Philippe Touffut** is co-founder and director of the Cournot Centre for Economic Studies. His research interests include probabilistic epistemology and the exploration of evolutionary games from a neurological and economic perspective.

# Preface

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This volume is one of a series arising from the conferences organized by the Cournot Centre for Economic Studies, Paris. The aim is to explore contemporary issues in economics. This conference, entitled ‘Augustin Cournot, Economic Models and Rationality’, was unique in that it focused on the pioneering work of nineteenth-century mathematician Antoine Augustin Cournot – namesake of the Cournot Centre – in the fields of economics, game theory, sociology and epistemology of probability and statistics. The contributors are from backgrounds as diverse as economics, mathematics, philosophy, statistics and history.

The conference, the Cournot Centre’s eighth, was held on 1–2 December 2005.

# Acknowledgements

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My warmest thanks go to Therrese Goodlett, Anna Kaiser and Timothy Slind, who greatly contributed to this book, from the organization of the conference from which these proceedings originated through to putting on the final touches. Special thanks go to Richard Crabtree for translations and to Stephanie Mansion for her help with the formatting of the texts and references. A heartfelt thanks to all of them.

The editor is grateful to The Nobel Foundation for permission to reprint Robert J. Aumann's Prize lecture 'War and peace'. ©The Nobel Foundation 2006.

# About the series

## Professor Robert Solow

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The Cournot Centre for Economic Studies is an independent French-based research institute. It takes its name from the pioneering economist, mathematician and philosopher Antoine Augustin Cournot (1801–77).

Neither a think-tank nor a research bureau, the Centre enjoys the special independence of a catalyst. My old student dictionary (dated 1936) says that catalysis is the ‘acceleration of a reaction produced by a substance, called the *catalyst*, which may be recovered practically unchanged at the end of the reaction’. The reaction we have in mind results from bringing together (a) an issue of economic policy that is currently being discussed and debated in Europe and (b) the relevant theoretical and empirical findings of serious economic research in universities, think-tanks and research bureaux. Acceleration is desirable because it is better that reaction occurs before minds are made up and decisions taken, not after. We hope that the Cournot Centre can be recovered practically unchanged and used again and again.

Notice that ‘policy debate’ is not exactly what we are trying to promote. To have a policy debate, you need not only knowledge and understanding, but also preferences, desires, values and goals. The trouble is that, in practice, the debaters often have only those things, and they invent or adopt only those ‘findings’ that are convenient. The Cournot Centre hopes to inject the findings of serious research at an early stage.

It is important to realize that this is not easy or straightforward. The analytical issues that underlie economic policy choices are usually complex. Economics is not an experimental science. The available data are scarce, and may not be exactly the relevant ones. Interpretations are therefore uncertain. Different studies, by uncommitted economists, may give different results. When those controversies exist, it is our hope that the Centre’s conferences will discuss them. Live debate at that fundamental level is exactly what we are after.

This particular conference is unique to the Series. Here the contribution and continued relevance of the Centre’s namesake, Augustin Cournot, is debated and elaborated. While this has the advantage of avoiding questions of short-term applicability, it is less evident what impact the subject may have on decision-

making processes or policy issues. Nevertheless, the subject has great relevance to the Centre's work.

Augustin Cournot's pluridisciplinary vision and approach are reflected in the Centre's activities. We all know Cournot's role in the development of mathematical modelling, industrial economics and game theory in the field of economics. It is less known, however, that Cournot's interests and contributions extended also to the fields of philosophy, history – in particular the history of philosophy – and, more generally, to the social sciences. Although it took sometimes several decades after his death for economists to begin to take notice of his knowledge and intuitions, Cournot has provided immeasurable inspiration to his successors the world over. Emphasizing the theoretical, economic and mathematical lineage from Cournot to the Centre focuses and highlights its work, inscribing the Centre's activities as part of Augustin Cournot's legacy.

I used the words 'serious research' a moment ago. That sort of phrase is sometimes used to exclude unwelcome ideas, especially unfashionable ones. The Cournot Centre does not intend to impose narrow requirements of orthodoxy, but it does hope to impose high standards of attention to logic and respect for facts. It is because those standards are not always observed in debates about policy that an institution like the Cournot Centre has a role to play.

# The complete works of Antoine Augustin Cournot

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Published under the direction of André Robinet, in collaboration with J. Vrin and the Centre National de la Recherche Scientifique (CNRS, France), with introductions and notes by the editors.

- I *Exposition de la théorie des chances et des probabilités* (1843), Bernard Bru (ed.) (1984), *Œuvres complètes*, Paris: Vrin.
- II *Essai sur les fondements de nos connaissances et sur les caractères de la critique philosophique* (1851), Jean-Claude Pariente (ed.) (1975), *Œuvres complètes*, Paris: Vrin.
- III *Traité de l'enchaînement des idées fondamentales dans les sciences et dans l'histoire* (1861), Nelly Bruyère (ed.) (1982), *Œuvres complètes*, Paris: Vrin.
- IV *Considérations sur la marche des idées et des événements dans les temps modernes* (1872), André Robinet (ed.) (1973), *Œuvres complètes*, Paris: Vrin.
- V *Matérialisme, vitalisme, rationalisme* (1875), Claire Salomon-Bayet (ed.) (1979), *Œuvres complètes*, Paris: Vrin.
- VI-1 *Traité élémentaire de la théorie des fonctions et du calcul infinitésimal* (1841), Pierre Dugac (ed.) (1984), *Œuvres complètes*, Paris: Vrin.
- VI-2 *De l'origine et des limites de la correspondance entre l'algèbre et la géométrie* (1847), Nelly Bruyère (ed.) (1989), *Œuvres complètes*, Paris: Vrin.
- VII *Des Institutions d'instruction publique en France* (1864), Angèle Kremer-Marietti (ed.) (1977), *Œuvres complètes*, Paris: Vrin.
- VIII *Recherches sur les principes mathématiques de la théorie des richesses* (1838), Gérard Jorland (ed.) (1980), *Œuvres complètes*, Paris: Vrin.
- IX *Principes de la théorie des richesses* (1863), Gérard Jorland (ed.) (1981), *Œuvres complètes*, Paris: Vrin.
- X *Revue sommaire des doctrines économiques* (1877), Gérard Jorland (ed.) (1982), *Œuvres complètes*, Paris: Vrin.
- XI *Pièces diverses et correspondance*, Bernard Bru and Thierry Martin (eds), in preparation.

## ENGLISH TRANSLATIONS OF COURNOT'S WORKS

Cournot, A.A. (1897) [1838], *Researches into the Mathematical Principles of the Theory of Wealth* [*Recherches sur les principes mathématiques de la théorie des richesses*], translated by N.T. Bacon with a Bibliography of Mathematical Economics by I. Fisher, New York: Macmillan.

Cournot, A.A. (1956) [1851], *An Essay on the Foundations of our Knowledge* [*Essai sur les fondements de nos connaissances et sur les caractères de la critique philosophique*], translated by M.H. Moore, New York: The Liberal Arts Press.

## EDITOR'S NOTE

With the exception of the two works cited above, all quotations from Cournot's writings are our translations.

# Chronological biography of Antoine Augustin Cournot

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28 August 1801	Birth in Gray (Haute-Saône); son of Claude-Agapit Cournot, merchant, descended from a long line of farmers
1809–16	Educated at the Collège des Jésuites in Gray
1820	Admitted to the Collège royal de Besançon for studies in mathematics
1821	Enters the École Normale Supérieure; the school is closed by the authorities one year later
1822	Undertakes undergraduate studies at the Sorbonne, particularly enjoying his courses with Lacroix and Hachette, and becoming friends with Dirichlet. Thanks to Hachette, has the opportunity to meet Ampère, Laplace and Lagrange. Regularly attends lectures at the Académie des Sciences, notably those of Poisson, Biot, Arago, Gay-Lussac, Poinsot, Berthollet, Legendre, Fourier et Cauchy
1823	Obtains a Bachelor's degree in science
1827	Obtains a Bachelor's degree in law
1823–33	Works as private tutor to the son of Marshal Gouvion-Saint-Cyr, whose memoirs he helps write

17 and 24 February 1829	Defends doctoral thesis
July 1834–October 1835	Holds the Chair of Mechanics and Analysis at the Faculté des sciences de Lyon
October 1835–September 1838	Rector of the Academy of Grenoble and Professor of Mathematics at the Faculté des sciences
1836	Succeeds Ampère as Matter’s assistant at the Inspection générale, in the post of Interim Inspector General
10 September 1838	Marries Colombe-Antoinette Petitguyot, with whom he has a son
September 1838–September 1854	Inspector General of Education
1839–43	Following Poisson, president of the jury overseeing France’s highest level of competitive examinations for teachers of mathematics
1848	Appointed to the Commission for Superior Studies
22 August 1854	Appointed Rector of the Académie de Dijon
May 1862	Retires from his post as Rector of the Académie de Dijon. Moves to Paris
1877	Death; buried 2 April at the Montparnasse cemetery, Paris



# Introduction

## Thierry Martin and Jean-Philippe Touffut

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If a symbolic date were to be chosen for the birth of mathematical economics, our profession, in rare unanimous agreement, would select 1838, the year in which Augustin Cournot published his *Recherches sur les principes mathématiques de la théorie des richesses*.

Gerard Debreu (1984, p. 267)

Economics has secured the posterity of Augustin Cournot's works, but there was a large temporal gap between their application and their original publication. Cournot's role in applying mathematics to the social sciences is an exceptional, and perhaps unique, contribution. Clearly ahead of his time, the nineteenth-century French mathematician found almost no interlocutors. The engineer–economists, for whom he wrote, had no need for his abstract and general approach, and the theoreticians simply ignored him. It was not until Walras, Jevons, Marshall or Pareto that Cournot found attentive readers who were eager to further his work. It is without a doubt Irving Fisher who introduced Cournot to economists in his 1898 commentary on the English translation of *Recherches sur les principes mathématiques de la théorie des richesses*, exactly 60 years after its original publication in French. In the second half of the twentieth century, the triumph of game theory consecrated Cournot's market theories, which were nonetheless marked by the ambiguities inherent in such a time lag. Finally, in 2008, Cournot's name will appear for the first time on the list of authors on secondary school biology syllabi in France.

Cournot's works have had such a vast influence on the social sciences that it would be futile to try to separate that which he would have recognized as a continuation of his work from that which he would have rejected. In and of itself, the question is of little interest, given that Cournot remained remarkably detached from his writings. The question gains pertinence, however, when one considers the contribution that his works have made to founding a normative discourse, a discourse that Cournot did not participate in. The aim of the conference proceedings presented in this book, however, is neither to legitimate one particular approach to research born from his works, nor to prove his paternity to developments born of his intuitions. The aim is above all to pay homage to

Cournot's originality and modernity in the area of social mathematics, and more precisely in the field of economics.

The specificity of Augustin Cournot's work does not reside in his use of mathematics to describe the properties of social phenomena. During his life, Cournot only made irregular contributions to the 'theory of wealth', and the very nature of the subjects of the moral sciences, as they were called at the time, invites quantification. He was, however, the first to construct a mathematical model enabling those subjects to be treated analytically. In *Recherches sur les principes mathématiques de la théorie des richesses* (1838) (published in English as *Researches into the Mathematical Principles of the Theory of Wealth* in 1897), he set out to establish that 'the solution of the general questions which arise from the theory of wealth, depends essentially not on elementary algebra, but on that branch of analysis which comprises arbitrary functions' (p.4). Cournot undertook this task 'from a purely abstract standpoint, without reference to proposed applications' (p.5). While Cournot is certainly not the Galileo of economics, we must recognize that, just as the founder of classical physics broke with his predecessors, not by applying mathematical instruments to physical reality, but by upholding the mathematization of its phenomena as an inescapable methodological principle, Cournot's approach initiated the mathematical modelling of social phenomena.

At the same time, he indicated the fundamental orientation of its relation to mathematics. He was not concerned with producing new results in that discipline, as a scientist seeking to invent or discover new theorems would be, or with applying them to a particular object, as an engineer would be, so much as with considering, in a theoretical and reflexive manner, the applicability of mathematics to phenomena, in other words with exploring its conditions and limits. Cournot was profoundly convinced of the intelligibility of mathematics. This was not prompted by mysticism or naïve Pythagorism on Cournot's part, first because he never reduced mathematics to the quantitative dimension, and second because he was clearly aware of the diversity of the subjects and methods that makes mathematics so rich.

The mechanism of knowledge is essentially a process of ordering. This may be limited to a distribution of objects into distinct categories according to various principles of classification, placing the objects in their reciprocal exteriority. This represents a first level of organization, necessary but not sufficient for the intelligibility of these objects, for it is no more than descriptive. We take a further step forward when we seek to clarify the relations of dependence and subordination between ideas, and between phenomena, on the basis of their constituent properties. Not only is such an order constructed logically; it is also, according to Cournot, *rational*, in the sense that we can use it to explain things. Not that this rational order can mysteriously reveal to us the very essence of things (assuming that this term actually means anything), but by identifying the

multiplicity of relations by which objects are linked, it reveals the different ways and degrees to which they are interdependent. What Cournot called the ‘fundamental ideas of mathematics’ play a decisive role in this ordering: concepts such as number, distance, volume and so on, on which the mathematical sciences rely. In *Essai sur les fondements de nos connaissances et sur les caractères de la critique philosophique* (1851), he specified that it ‘is to be noted that many of these ideas, in spite of their high degree of generality and abstraction, are only particular forms and, as it were, concrete species of ideas still more abstract and general’ (1956 [1851], p. 233), such as combination, order, symmetry, inclusion, exclusion and so on.

Because of their high degree of generality, these ‘even more abstract’ ideas reach beyond the field of mathematics. They also form the basis of logic, and thus constitute the foundation of the formal sciences, which are characterized by their independence from any specific content or empirical determination. Cournot could not express himself in these exact terms, but this is the very conception that he proposed by invoking a ‘theory of order and form’. Moreover, it is precisely because of their independence, and therefore their formal character, that mathematical ideas are so fertile. These fundamental mathematical ideas designate formal, general relations between symbols, which can then be applied to the study of the relations between phenomena.

What is true for natural phenomena is equally valid for economic and social events. This is a first consequence of the above argument. The formal and symbolic character of mathematical ideas liberates them from any specific empirical content, so that they are capable of describing the diverse forms of relations between elements in any domain. Cournot actually applied this thesis, before formulating it explicitly, as early as 1838, in *Recherches*.

This does not mean, however, that the various mathematical sciences can be successfully applied indiscriminately to each domain of objects, or, to put it more clearly, to each of the different disciplines they study. We know that Cournot attached particular importance to two main branches of mathematics: infinitesimal calculus on the one hand, and probability calculus and statistics on the other. Two questions then arise. First, how did Cournot himself envisage the fertility of these instruments when applied to the investigation of social phenomena? Second, and more broadly, what has been the legacy of Cournot’s development of these instruments in the field of economics? More specifically, what remains, today, of the impetus given by Cournot to the mathematical modelling of the economy?

One may wonder whether fundamental mathematical ideas are pure intellectual constructions enabling a set of operations to be performed on the symbols that they both connect and designate, thanks to which we can then identify and classify the relations between phenomena, or whether these ideas are discovered by the mathematician, rather than invented, because they stem from the very

'nature of things' and are somehow 'realized' by phenomenal relations. Whatever Cournot's position on this point, he believed that fundamental mathematical ideas formally designate general relations of order that *correspond* to the general relations that link phenomena to each other, and thus bring intelligibility. 'The mind', he wrote in 1872 in *Considérations sur la marche des idées et des événements dans les temps modernes*, 'discovers mathematical truths through its own powers, and considers them as necessary truths: after which, in fact much later, the observer proves that the truths thus discovered do indeed explain and govern natural events' (1973, p. 415–16).

Finally, the central motivation driving Cournot's epistemological reflection is the desire to elucidate the significance and scope that can be attached to the applications of mathematics. He stressed this problem repeatedly: whereas mathematicians easily agree about the methods that should be used to obtain a result, they differ about the way that we should interpret its application to experience. Above all, Cournot devoted himself to forestalling the risk of confusion between an artificial process and a property of the object under study, or of the mistaken projection onto the object of characteristics inherent to the conceptual instrument used and the way it is implemented. Here, Cournot displayed an epistemological perceptiveness, the continuations and echoes of which we shall seek to discern in contemporary thought.

Our aim is not historiographical. We do not seek to reproduce Cournot's thought as faithfully as possible for its own sake by comparing the diverse interpretations to which it has given rise, but instead to assess the relevance of his heritage, and therefore his topicality, on the epistemological, methodological and doctrinal levels. There is nothing self-evident about this heritage. When *Recherches* was published in 1838, it went almost completely unnoticed. Cournot's later economic writings, *Principes de la théorie des richesses* (1863) and *Revue sommaire des doctrines économiques* (1877), stripped of the mathematical apparatus, did not meet with any warmer reception. Yet in the early 1940s, his contributions to economic theory were widely recognized and discussed. To what can we attribute this tardy recognition? What do we retain, today, from Cournot's economic work? And, more broadly, how does it improve our conception of the relation between mathematics and experience?

These are the questions we shall be addressing in this work, in which economists, mathematicians, philosophers and statisticians have been invited to measure the legacy of Cournot's work in the twenty-first century. The probabilistic approach lies at the heart of Cournot's thought, not only because, as a mathematician, he wrote a treaty devoted to this branch of the discipline, *Exposition de la théorie des chances et des probabilités* (1843), but also because his epistemology is founded on the assertion that the relation of the theoretical hypotheses that constitute scientific knowledge to empirical reality can only be affirmed probabilistically, philosophical reflection then serving to evaluate, in