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RESEARCHES
INTO THE
MATHEMATICAL PRINCIPLES
OF THE
THEORY OF WEALTH

BY
AUGUSTIN COURNOT

1838

TRANSLATED BY NATHANIEL T. BACON
WITH A
BIBLIOGRAPHY OF MATHEMATICAL ECONOMICS
BY IRVING FISHER

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ANTOINE AUGUSTIN COURNOT was born at Gray, in Haute-Saône, France, on Aug. 28, 1801. He received his early schooling in his native town, and his first special discipline in mathematics at the Lycée de Besançon. In 1821 he entered the École Normale at Paris, where he continued his mathematical studies. He became Professor of Mathematics at Lyons in 1834, and the year following Rector of the Academy at Grenoble. In 1838 appeared his *Recherches sur les principes mathématiques de la théorie des richesses*, of which the present work is a translation. In the same year Cournot was called to Paris as Inspecteur Général des Études. He was made Knight of the Legion of Honour in 1838, and Officer in 1845. He became Rector of the Academy at Dijon in 1854, but in 1862 retired from active teaching. From this time to the end of his life he was busily engaged in writing. His *Principes mathématiques* having met with little or no success, in 1863 he paraphrased it in popular language under the title *Principes de la théorie des richesses*, which was further amplified in 1876 as *Revue sommaire des doctrines économiques*. He died in the following year, on March 31, in Paris.

Among Cournot's mathematical writings may be mentioned his *Traité élémentaire de la théorie des fonctions et du calcul infinitésimal*, 1841; *De l'origine et des limites de la correspondance entre l'algèbre et la géométrie*, 1847; and *Exposition de la théorie des chances et des probabilités*, 1843. In the last-named work he showed how to apply the theory of chances to Statistics.

Cournot also produced several philosophical works, e.g. *Traité de l'enchaînement des idées fondamentales dans les sciences et dans l'histoire*, 1861; and *Considérations sur la marche des idées et des événements dans les temps modernes*, 1872. He also translated some English mathematical books, including Sir John Herschel's *Astronomy*, and edited in two volumes Euler's celebrated *Letters to a Princess*, etc.

For the facts of Cournot's life see Liard, *Revue des Deux Mondes*, July, 1877; and *Nouvelle Biographie Générale*. For criticisms of his work in economics see Palgrave's *Dictionary of Political Economy*; and the prefaces of Jevons's *Theory of Political Economy* (second edition), Walras's *Éléments d'économie politique pure*, Auspitz and Lieben's *Untersuchungen über die Theorie des Preises*, and Marshall's *Principles of Economics*; also an article by Vilfredo Pareto, *Di un errore del Cournot nel trattare l'economia politica colla matematica*, in the *Giornale degli economisti*, January, 1892, and one by Edgeworth, *La teoria pura del monopolio, ibid.*, July, 1897. The present writer will shortly publish in the *Quarterly Journal of Economics* an article critical and explanatory of the *Principes mathématiques*, and intended especially for the use of those who may wish to follow the reasoning of the work in detail, but lack the requisite familiarity with mathematics. He is also preparing a brief Introduction to the Calculus for a similar purpose.

In rendering the book into English, the translator (Mr. Nathaniel T. Bacon, of Peacedale, R.I.; Ph.B., Yale, 1879) has tried to be as literal as possible, and to retain the slight archaism of the French. He has also followed out the mathematical operations with great care, and in so doing discovered a surprisingly large number of errors. Most of these were misprints; others were due to obvious careless-

ness of the author, while still others were doubtful as to their origin. All have been corrected except two, which were the only ones seriously affecting the argument. These are formulæ (6) on page 122, and the next but last inequality on page 158. The true formulæ may be transcribed from (6), page 122, by substituting zero for ϵ ; and the inequality on page 158 may be corrected by reversing the sign of inequality. The conclusions which follow each passage must be materially modified.

For nearly forty years the *Principes mathématiques* was completely ignored by economists. The writers chiefly instrumental in reviving the work were Jevons, Walras, and Boccardo. At present, though mathematico-economic works are not yet widely read, Cournot's treatise is diligently studied by a few, and exercises a very definite and powerful influence on economic thought. Professor Edgeworth says of it in Palgrave's *Dictionary*, that it "is still the best statement in mathematical form of some of the highest generalisations in economic science"; while Professor Marshall, in the preface to his *Principles*, declares that "Cournot's genius must give a new mental activity to every one who passes through his hands."

The bibliography of mathematical economics is, of course, founded on that appended to Jevons's *Theory of Political Economy*. A number of writings in the latter list have been omitted, as they did not make use of symbols. Even the *Volkswirtschaftslehre* of Menger, who shares with Jevons and Walras the honour of independently developing the theory of marginal utility, has not been included, as it must properly be credited to the literary and not the mathematical method. Jevons's list has also been carefully revised and corrected, as well as continued to 1897.

The bibliography divides itself very naturally into four periods, beginning respectively with the treatises of Ceva, Cournot, Jevons, and Marshall. Ceva enjoys the distinction of being the first known writer to apply mathematical method to economic problems; Cournot was apparently the first to apply it with any great degree of success; Jevons (and almost simultaneously Walras) attracted the serious attention of economists to this method; and Marshall brought it (or at any rate its simpler diagrams) into general use. The four periods are of constantly decreasing length, being respectively 127, 33, 19, and 8 years, but the number of titles grows greater in each succeeding period. It will also be observed that the variety of subjects to which the mathematical method is being applied shows a rapid increase, that the number of complete economic treatises has grown relatively less, and that the mass of literature on transportation has first risen and then fallen relatively to the total writing.

In preparing the work for the press, important aid has been rendered by Mr. John M. Gaines, of the graduate department of Yale University. Mr. Thomas G. Barnes, Mr. James O. Moore, and especially Mr. William B. Bailey, also students at Yale, have contributed materially in the formation of the bibliography. Grateful acknowledgments are due to the many other persons who have supplied bibliographical data, and in particular to Professors Pantaleoni, Walras, Pareto, and Edgeworth.

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PREFACE

THE science known as Political Economy, which for a century has so much interested thinkers, is to-day more generally diffused than ever before. It shares with politics proper the attention of the great journals, which are to-day the most important means of spreading information; but the public is so tired of theories and systems that now the demand is for so-called "positive" matter, *i.e.* in political economy, custom-house abstracts, statistical documents, and government reports, such as will throw the light of experience on the important questions which are being agitated before the country, and which so greatly interest all classes of society.

I make no objection to this tendency; it is good, and in accord with the laws which govern the development of all branches of science. I will only observe that *theory* ought not to be confounded with systems, although in the infancy of all sciences the instinct of system necessarily attempts to outline theories. I will add that theory should always have some part, small though it may be, in the development of a science; and that, to a man of my profession in particular, more than to any other, it should be permissible to consider from an exclusively theoretical

standpoint, a subject of general interest which has so many different sides.

But the title of this work sets forth not only theoretical researches; it shows also that I intend to apply to them the forms and symbols of mathematical analysis. This is a plan likely, I confess, to draw on me at the outset the condemnation of theorists of repute. With one accord they have set themselves against the use of mathematical forms, and it will doubtless be difficult to overcome to-day a prejudice which thinkers, like Smith and other more modern writers, have contributed to strengthen. The reasons for this prejudice seem to be, on the one hand, the false point of view from which theory has been regarded by the small number of those who have thought of applying mathematics to it; and, on the other hand, the false notion which has been formed of this analysis by men otherwise judicious and well versed in the subject of Political Economy, but to whom the mathematical sciences are unfamiliar.

The attempts which have been made in this direction have remained very little known, and I have been able to learn only the titles of them, except one, *Les Principes de l'Économie Politique*, by *Canard*, a small work published in the year X [of the French Republic, A.D. 1801], and crowned by the *Institut*. These pretended principles are so radically at fault, and the application of them is so erroneous, that the approval of a distinguished body of men was unable to preserve the work from oblivion. It is easy to see why essays of this nature should not incline such economists as Say and Ricardo to algebra.

I have said that most authors who have devoted them-

selves to political economy seem also to have had a wrong idea of the nature of the applications of mathematical analysis to the theory of wealth. They imagined that the use of symbols and formulas could only lead to numerical calculations, and as it was clearly perceived that the subject was not suited to such a numerical determination of values by means of theory alone, the conclusion was drawn that the mathematical apparatus, if not liable to lead to erroneous results, was at least idle and pedantic. But those skilled in mathematical analysis know that its object is not simply to calculate numbers, but that it is also employed to find the relations between magnitudes which cannot be expressed in numbers and between *functions* whose law is not capable of algebraic expression. Thus the theory of probabilities furnishes a demonstration of very important propositions, although, without the help of experience, it is impossible to give numerical values for contingent events, except in questions of mere curiosity, such as arise from certain games of chance. Thus, also, theoretical Mechanics furnishes to practical Mechanics general theorems of most useful application, although in almost all cases recourse to experience is necessary for the numerical results which practice requires.

The employment of mathematical symbols is perfectly natural when the relations between magnitudes are under discussion ; and even if they are not rigorously necessary, it would hardly be reasonable to reject them, because they are not equally familiar to all readers and because they have sometimes been wrongly used, if they are able to facilitate the exposition of problems, to render it more concise, to

open the way to more extended developments, and to avoid the digressions of vague argumentation.

There are authors, like Smith and Say, who, in writing on Political Economy, have preserved all the beauties of a purely literary style ; but there are others, like Ricardo, who, when treating the most abstract questions, or when seeking great accuracy, have not been able to avoid algebra, and have only disguised it under arithmetical calculations of tiresome length. Any one who understands algebraic notation, reads at a glance in an equation results reached arithmetically only with great labour and pains.

I propose to show in this essay 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, which are merely restricted to satisfying certain conditions. As only very simple conditions will be considered, the first principles of the differential and integral calculus suffice for understanding this little treatise. Also, although I fear that it may appear too abstruse to most people who have a liking for these topics, I hardly dare to hope that it will deserve the attention of professional mathematicians, except as they may discover in it the germ of questions more worthy of their powers.

But there is a large class of men, and, thanks to a famous school, especially in France, who, after thorough mathematical training, have directed their attention to applications of those sciences which particularly interest society. Theories of the wealth of the community must attract their attention ; and in considering them they are sure to feel, as

I have felt, the need of rendering determinate by symbols familiar to them, an analysis which is generally indeterminate and often obscure, in authors who have thought fit to confine themselves to the resources of ordinary language. In thinking that they may be led by their reflexions to enter upon this path, I hope that my book may be of some use to them, and may lessen their labour.

In the remarks on the first notions of competition and the mutual relations of producers, they may possibly notice certain relations, which are very curious from a purely abstract standpoint, without reference to proposed applications.

I have not set out to make a complete and dogmatic treatise on Political Economy; I have put aside questions, to which mathematical analysis cannot apply, and those which seem to me entirely cleared up already. I have assumed that this book will only fall into the hands of readers who are familiar with what is found in the most ordinary books on these topics.

I am far from having thought of writing in support of any system, and from joining the banners of any party; I believe that there is an immense step in passing from theory to governmental applications; I believe that theory loses none of its value in thus remaining preserved from contact with impassioned polemics; and I believe, if this essay is of any practical value, it will be chiefly in making clear how far we are from being able to solve, with full knowledge of the case, a multitude of questions which are boldly decided every day.

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(1871-1889)

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FROM MARSHALL TO THE PRESENT TIME

(1890-1897)

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