Antoine Cournot

Some may scoff at the suggestion that economics is a mathematical discipline, but it has been so at least from the time of the French mathematician, economist and philosopher **Antoine Augustin Cournot (**August 28, 1801 – March 31, 1877). In his principal work *Recherches sur les Principes Mathématiques de la Théorie des Richesses* (*Researches into the Mathematical Principles of the Theory of Wealth*, 1838), he introduced an important class of mathematical models describing competitive behavior in the market place. His legacy is showing economists how to use mathematics to develop economic theory. The work was not embraced during his lifetime; in fact it was severely criticized. It was far too advanced at a time when economists studiously avoided mathematics. Mathematics was not generally integrated into the mainstream language and analysis of economists until the second half of the 20th century. Today many economists laud his book as the midwife of modern economic analysis. Cournot's contributions are heralded as forerunners for mathematical game theory, which is used for describing strategic interaction between business firms, tacticians or diplomats.

Born in Gray, Haute-Saône, Cournot attended the Collège de Gray from 1809 to 1816. After graduation from the secondary school he worked in an attorney's office for four years. Inspired by the work of Pierre de Laplace, Cournot realized that he would have to learn mathematics if he wanted to follow his philosophical aspirations. As a result, he concentrated on mathematics at Collège Royal in Besançon and in 1821 entered the teachers' training college École Normale Supérieure. However, political unrest forced the closure of the school. Together with fellow student Lejeune Dirichlet, Cournot transferred to the Sorbonne, where he supported himself by tutoring. In 1829 he received his doctorate in

mathematics, with a thesis *Le mouvement d'un corps rigide par un plan fixe*, mainly on mechanics and astronomy.

Impressed with Cournot, Siméon Denis Poisson arranged for his appointment to a position with the Academy in Paris. It was at this time that Cournot translated John Herschel's *Astronomy* (1834) and Dionysus Lardner's *Mechanics* (1835). Throughout his career Cournot jointly held positions as a professor of analysis and mechanics and high posts in the French government. Again through the influence of Poisson, he was made Inspecteur Général des Études (inspector general of public education) in 1838, the same year he was made a Knight of the Légion d'Honneur (he was elevated to an Officer in 1845). This was also the year he published his mathematical views in his masterpiece, the . In it he introduced function and probability to economics and brought to bear his background in mechanics to seek general principles for economics. He is credited with the introduction of the theory of profit maximizing producers, that is, he assumed that participants in the exchange process share the goal of wishing to maximize monetary profit. He derived the first formula for the rule of supply and demand as a function of price. In addition, he considered conditions for equilibrium with *monopoly*, *duopoly*, and *perfect competition*. He also advanced the opinion that the practical uses of mathematics in economics need not involve strict numerical precision.

Today Cournot's work is associated with a discipline called econometrics, which is the art and science of making measurements in economic theory and applying them to realistic situations. In econometrics the goal is to recast mathematical economics into a stochastic form. Economic relationships can only be estimated based on sample observations. There are many dependent variables at work in economic relationships and also many relationships simultaneously generating non-experimental samples of data. Estimation of economic relationships using methods of statistical inference is not the only approach of econometrics. Russian economist Wassly Leontief developed a departure from the statistical inference

aspect of econometrics, by employing input-output analysis. It has proved to be useful in development planning for emerging countries and in emergency planning for developed countries.

Cournot's duopoly mathematical model concerns two rival producers of a homogeneous product. Each producer knows that his competitor's decision as to the quantity of the product to make will also impact the price he or she faces and thus the profits. Consequently, each producer chooses a quantity that maximizes his or her profits subject to the quantity reactions of the competition. The price that emerges clears the market, that is, demand equals supply. Cournot's duopoly work led to his oligopoly solution concept, which was an earlier manifestation of the non-cooperative equilibrium concept of game theory that earned John Forbes Nash, Jr., his Nobel Prize. Cournot believed that economists should use mathematics only as a means of establishing probable limits and to express less stable facts in more absolute terms.

In 1843 Cournot published *Exposition de la Théorie des Chances et des Probabilitiés*, a seminal work, which linked statistics with probability, previously two relatively unconnected areas of mathematics. He offered a definition of chance as the intersection of two independent streams of events. During the second half of the 19th century, Cournot's views concerning the link of probability and statistics were confirmed in the realm of physics, in the work of Ludwig Boltzmann, James Clerk Maxwell, and J. Willard Gibbs.

The members of the French Liberal School, who at the time dominated economics in France, deliberately took no notice of Cournot's work, leaving him crushed and bitter. After the 1848 Revolution, he was appointed to the *Commission des Hautes Études*, about the time he wrote his first treatise of the philosophy of science (1851). Three years later, he became rector of the Academy at Dijon. In 1863 he wrote *Principes de la Théorie des Richesses*, which was essentially his *Recherches*

without the mathematics and in more readable prose. Once more, his work was completely neglected, increasing his bitterness. His demeanor was described as solitary and melancholy, and this influenced his writing. His spare books abounded with facts and rigorous mathematical proofs, which was not likely to enchant economists of the day.

Among the first to recognize the importance of Cournot's work was English economist and logician William Stanley Jevons. In his *Theory of Political Economy* (1871), Jevons moved the work begun by Cournot along to a point where the importance of mathematics in economics became readily accepted. In 1874 Léon Walras, whose father Auguste had been a student of Cournot, formulated the problem of general equilibrium in economics as finding a solution of a set of simultaneous equations. The "law of supply-and-demand" is given explicit mathematical formulation to handle the problem of the conditions of stable equilibrium. It is assumed that in a competitive society, if there is an excess of supply in any market, the price falls and similarly if there is an excess demand, the price rises. The corresponding mathematical formulation is a system of differential equations. Conditions under which the solutions of such systems are stable have been derived.

Quotation of the Day: "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." – Antoine Cournot