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W.S. JEVONS AS THE FOUNDER OF MODERN ECONOMICS

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ÖZET

XIX. yüzyılın ortalarından itibaren ekonomik teorilerin ilgi odağı, makroekonomik (büyüme ve gelir dağılımı) sorunlarının tartışmasından mikroekonomik (firma ve tüketici teorileri) problemlerin tanımlanmasına doğru kaymıştır. Bu yeni yaklaşımın kökenleri Fransız ekonomist ve mühendislerine uzanmasına rağmen, aslında bu neoklasik teoriler İngiliz, Alman ve Fransız araştırmacılar tarafından geliştirilmiş ve bu çalışmalar literatürde aynı zaman diliminde görülmeye başlanmıştır. İktisadi düşünceler tarihindeki bu gelişimin en güzel örneğini birbirinden bağımsız çalışan Jevons, Merger ve Walras'ın çalışmaları sergilemektedir. Bu üçlü iktisadi düşünceler tarihinde Marjinal Fayda Hareketinin kurucuları olarak anılır ve inançları, düşünceleri ve kullandıkları teknikleri açısından da benzer olarak aynı grubta değerlendirilmişlerdir. Bazı iktisadi düşünce tarihçileri ise, bu üçlünün aynı doğrultuda karşılaştırılamayacağını, çünkü önemli farklılıklar teşkil ettikleini öne sürmüşlerdir. Bu tartışma çerçevesinde, William Stanley Jevons'ın mikroekonomiye katkıları ve ekonomik analizde ki matematiksel etkileri, bu çalışma ile ortaya konulmuştur.

1. INTRODUCTION

In the middle of the nineteenth century, the focus of economics theory changed from macroeconomics (questions of economic growth and income distribution) to microeconomics (the decisions of the firm and the individual consumer). Although this new approach was originated by French economist and engineers, in fact, founders of neo-classical theory were multiple writers of English, German and French. Furthermore, despite of the fact that their works in the literature appeared at the same period, their discoveries were more-or-less simultaneous. The publication of Jevons's " *Theory of Political Economy* " and Carl Menger's "*Grundstze der Volkswirtschaftslehtre*" came in 1871. Leon Walras's "E*lements d'economie politique pure* " was published in 1874. These three are one of the best

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examples of multiple discoveries in the history of economic thought. Each of these professors of political economy –Jevons at Manchester, Menger at Vienna, Walras at Lausanne- had independently arrived at the principle of diminishing marginal utility and proclaimed this insight to be the cornerstone of significantly new science of economics. These three was called co-founders of the " Marginal utility revolution."

Some the historians of economic thought homogenized these three economists in their beliefs, values, techniques etc. They interpret the marginal revolution of the 1870s as a paradigm change in the sense that T.S. Kuhn uses the term in his analysis of the structure of scientific revolutions. Kuhn's view of a scientific community consists of the practitioners of a scientific specialty who share a common paradigm. So that, marginal revolution is applied by the these historians of economic thought to methodological changes that took place in the mainstream economics in the fourth quarter of the nineteenth century and fits into the grand role of a total *Gestalt* shift.

Opponents pointed out the difficulties in treating Jevons, Menger and Walras as a united front in the history of economics thought. Furthermore, some historians, such as Mark Blaug, denied categorically that revolution happened that time. Blaug has stated that " (i) the "marginal revolution" was a process, not an event; (ii) there was no "multiple" discovery of marginal utility, but only temporal coincidence of three or more singletons; and (iii) the success of revolution is intimately associated with professionalization of economics.... and it is this which constitutes the problem that must be explained by historians of economic thought," at a conference held at the Villa Serbelloni, Bellagio, Italy, August 22-28, 1971. [Black, Coats and Goodwin (1973) p. page # 14].

Since the 1970s, however, scholars have begun to question this account. William Jaffe complained that the tendency to homogenize these three pioneers obscured important differences among them and has argued that each of these economists, working in isolation from one another, built upon distinct intellectual traditions and drew different implications from the principle of marginal utility. He has stated that "the seeds of subsequent developments in economic theory found in Menger were very different from those found in Jevons and Walras," in his article " *Menger, Jevons, and Walras De-Homogenized*," [W. Jaffe (1976) p. page #523]. Erich Streissler has also done much to separate Menger from Walras and Jevons, primarily because of his disdain for mathematics in his article "*To What Extent was the Austrian School Marginalist?*" [E. Streissler, (1972) p. page 426-41].

Nowadays, Robert F. Hebert argues that Walras was the real odd man out and stated that "the tendency to homogenize Jevons, Menger and Walras emerged as a consequence of misunderstanding the fundamental nature of the paradigm shift from "classical" to "neoclassical" economics. The significant key developments in economics theory after 1850 was not so

much that utility found its way into economists' thinking but that the onus of explanation shifted from macroeconomic to microeconomic", in his article "*Jevons and Menger re-homogenized: Who is the real " odd man out"? A Comment on Peart"* [R. Herbert (1998) p. page 327-32]. He made very important starting point in this endless debate. In my opinion, if we take the history into mathematical concept it could be represented as a differential function, not a difference function, since it contains continuous, not a discrete phoneme. It is true that Menger, Walras, and Jevons were working in a similar direction in same period, because their achievement was originated to econo-engineering tradition.

If one looks only at Britain, however, a strong case can be made for a "Jevonian Revolution." Until Jevons, Britain economic thought from Lock to Mill formed one long unbroken tradition. In this respects Jevons' work was superior to that of Menger and Walras. Perhaps if Jevons had never lived, it would have meant only that English economics would have made slower progress. Therefore, it may be right to acclaim Jevons as "The Founder of Modern Economics." This difference of William Stanley Jevons from other so-called marginal revolutionist make me focus on his contributions in microeconomics and mathematical influence in economic analysis.

2. JEVONS'S LIFE

Jevons was born in Liverpool on September 1, 1835. He was educated at University College, London, and in 1854 became an assayer of the Mint in Sydney. In 1863 he was appointed Lecturer at Owens College, Manchester, and, in 1866, Professor of Logic, Mental and Moral Philosophy. Between 1876 and 1880 he occupied a Chair at University College, London, and 1882 his brilliant career was tragically cut short by drowning.

Both his parents were Unitarian and solidly middle-class. He was raised in Unitarian environment in which economic and social problems were often discussed. Jevons's mother, Mary Anne, was a woman of exceptional intelligence and fortitude. Before her marriage at age of thirty, she had assisted her father in his literary endeavors and published two books of her own poetry. Jevons was tutored at home until his mother died and then spent two years at Liverpool Mechanics Institute. This was followed by two years at Mr. Beckwith's day school where the emphasis on classics was not to Jevons's liking. At fifteen, he was sent to Junior School of University College, London. For two years, he lodged with his cousin, Henry Enfield Roscoe, who later became one of Britain's most eminent chemists. Harry exerted considerable influence over Jevons and was to have a hand in many of his professional advancements.

Jevons's studies went well and he received a number of prizes, including the gold medal in chemistry and top honors in experimental philosophy. His courses in mathematics were taught by one of the leading mathematicians of the time, Augustus De Morgan. Toward the end of his second year, Jevons arranged to secure a good starting position with chemical firm. It is entirely not clear, why he was unable to stay third year to complete his degree. He spent the summer of 1853 working as an assistant to Thomas Graham, the professor of the theoretical chemistry, and, best known for his research in diffusion of gases and liquids and in colloid chemistry, and by early October was certified to be a capable assayer. While awaiting news of completion of the Sydney mint, he spent two months in Paris where he received the diploma from French mint. After a year or two his work in Australia, the demands for assaying at the mint slackened off and he was free to devote more time to scientific investigations. For almost three and half years he kept daily meteorological records and for one of those years, was the only weather recorder in Sydney. During those first years in Australia, he also wrote two unpublished books, one a social survey of Australian cities and the other on music theory.

Five years in Australia were of fundamental importance to Jevons's intellectual development. In 1856, a dispute over the funding of the first railway for New South Wales sparked his interest in economics. Jevons began to read Adam Smith, John Stuart Mill, Thomas Robert Malthus, Richard Whately, and Harriet Martineau. Jevons also got a copy of Dionysius Lardner's Railway Economy (1850), that contained a geometrical treatment of supply and demand and notions of marginal cost and revenue. There are certain personal indications that may also account for Jevons's transition from the natural to the social sciences during his Australian years. His father's death in 1855, Jevons experienced something of a religious crisis. In 1858, he confessed to his sister Henrietta: "do not misunderstand me when I say that I am in some respects an Atheist. . . . On the other hand . . . I almost Deify the love of Man." Prolonged reflection on his beliefs and the nature of morality fostered an interest in the human sciences. Jevons also reflected on the problems of ethics and human agency. In 1856, he wrote "I regard man in reality as essentially selfish, that is as doing everything with a view to gain enjoyment or avoid pain. This self-interest is certainly the main-spring of all his actions." in letter to his sister. It sounds like Jeremy Bentham's views on human nature. After reading Quetelet's *Treatise on Man* in 1857, he acknowledged that "each individual man must be a creature of cause and effect."

Jevons returned to England in 1859 and joined as a student at University College and studied mathematics and political economy. In June of 1860, he took the college examinations in two subjects, mental philosophy and political economy and a few months later won the Ricardo Scholarship of sixty pound based on special examination. By June 1862, following a year, Jevons was awarded the gold medal for the master of logic, moral and political philosophy, the history of philosophy, and political economy. While

working toward the MA, Jevons continued to study mathematics and natural philosophy. He repeated De Morgan's course in upper senior mathematics, thereby acquiring a fair grounding in the calculus and in its application to mechanics. During these years, he published a number of articles on the natural science and had discovered the essential elements of what was to become his mathematical theory of economics.

At that time, in England mathematics was usually taught in its mixed rather than pure form, that is, within the context of problems in physical sciences. Geometry, algebra, and the calculus primarily comprised in the subject. At Cambridge, despite some protestations in the 1810s, Euclidean geometry dominated the curriculum well into latter half-century. Preparation for mathematics tripos culminated in a study of Newton's *Principia,* rather than the continental texts on the calculus. This seemingly antiquated program survived for so long because it was thought to best serve the objectives of liberal education. A study of traditional mathematics instilled an appreciation for the nature of truth itself and thus prepared a young man for the clergy or courtroom. The very a few who wished to advance mathematics or physics had to learn their skills elsewhere. Jevons was fortunate to have studied under Augustus de Morgan and thus been exposed to more recent branches of mathematics.

By 1861, Jevons had begun to develop his own system of logic and had most certainly discerned the main elements of his utility theory of value. To his brother Herbert he wrote:

"During the last session I have worked a great deal at Political economy; in the last few months I have fortunately struck out what I have no doubt is the true theory of Economy so thorough- going and consistent, that I cannot now read other books on the subject without indignation. While the theory is entirely mathematical in principle, I show at the same time how data of calculation are so complicated as to be for the present hopeless. Nevertheless I obtain from the mathematical principles all the chief laws at which Political Economists have previously arrived only arranged in a series of Definitions Axioms and Theorems almost as rigorous and connected as if they were so many geometrical problems. One of most important axioms is that as the quantity of any commodity, for instance plain food, which a man has to consume increases, so the utility or benefit derived from the last portion used decreases in degree… And I assume that on an average the ratio of utility is some continuous mathematical function of quantity of commodity. This law of utility has fact always been assumed by Political Economy under the more complex form and name of the Law of Supply & Demand. But fairly stated in its simple form it opens up the whole subject. Most of conclusions are of course the old ones stated in consistent form- but my definition of Capital and Law of Interest of Capital are as far as I have seen quite new. I have no idea of letting these things lie by till somebody else has advantage of them- and shall therefore try to publish them next Spring."

The entire passage shows that his indignation at other treatments of the subject and it is also clear that Jevons found his new principle of his theory of utility. This early period was especially fruitful for him. In several communications to the British Association, he outlined the main structure of his utility theory and his statistical studies of fluctuations. In 1863, shortly after Jevons settled in Manchester, his first book, A *Serious Fall in the Value of Gold* published. His work was impact of the Australian and Californian gold discoveries on price. It was one of the most important statistical works and investigation in applied economics. He started to explain the meaning of the average rise of the prices and method of constructing price indices, and then, investigated the fall in the value of gold. He used arithmetic and geometric mean for combining observation on price change and provided serious improvement on notion of index number and on the nature of sampling techniques. In 1864, Jevons had been elected to Statistical Society of London and 1865 published *Coal Question.*

The Coal Question was based upon the prediction in a Malthusian fashion the depletion of Britain's coal reserves and subsequent economic decline. It brought him to notoriety in economic circles. A Royal Commission was established to investigate the matter and, then proposed the reducing national debt. At this term, his professional standing also improved significantly. By May 1866, with supporting letters from De Morgan, Herschel, Mill, and Herbert Spencer, Jevons was appointed Cobden Professor of Political Economy, and Professor of Logic, Mental and Moral Philosophy at Owens College. He was to occupy the chair for ten years, until his return to University College, London as Professor of Political Economy.

Shortly after his marriage, Jevons began to write his *Principles of Science*, which built directly upon his insights on logic. It was to take seven years to finish, due to frequent bouts of illness and six-month interruption, in 1871, to write his *Theory of Political Economy*. Apparently, he rushed off the *Theory* for fear of losing some of the glory to Fleeming Jenkin, who in 1870 had sent Jevons a short but incisive paper on mathematical economics. After completing and publishing his *Principle* in 1874, Jevons resumed work on applied economics. His next book, *Money and the Mechanism of Exchange* (1875) was well received and became a standard text in university curricula well into the early part of our century. In 1875, he also published his celebrated sunspot theory of business cycle, though the original notion dates back to his student days. Over the next seven years, until his premature death in 1882, Jevons was to write to more texts on logic, *Primer of Logic* (1876) and *Studies in Deductive Logic* (1880) and another on the economic policy, *The State in Relation to Labour* (1882). Most of his remaining essays and manuscripts on economic topics were published posthumously*: Methods and Social Reform* (1883), *Investigations in Currency and Finance* (1884), *Pure Logic and Other Minor Works* (1890), and *The Principles of Economics* (1905).

In the years previous to the publication of Jevons's greatest work on economic theory, *Theory of Political Economy*, English economic thought was dominated by the Classical tradition. Gossen and Cournot had yet to be discovered, Galiani and Condillac were forgotten. True, Bailey, Thornton, Rae, MacLeod, and others had started vigorous polemics against classical doctrines. Perhaps the trend towards a psychological attack had begun. Nevertheless, something rather extraordinary was necessary to rescue English economic theory from the hold of the Classical School, and thus prevent retardation of progress. Jevons's *Theory of Political Economy* performed this function and tilted the methodological scales definitely in favor of a subjective approach.

Jevons was active citizen in scientific organizations. In 1870, he served as president of section F of the British Association for the Advancement of science and, in 1872,was appointed a member of the Royal Society. In 1876, after numerous bout of nervous and physical exhaustion, Jevons left Manchester for a professorship in political economy at University College in London. Upon moving back to London, he became an active member of the Political Economy Club and in 1879, joined the Athenaeum Club. Jevons taught at University College for only five years. Poor health led him to resign in 1881 and to decline other public engagements. Although his health continued to deteriorate, he lived long enough to have the satisfaction of witnessing the widespread approval of his innovations in economic theory. In these last years of his life he acquired a sizable following and befriended many of leading economists of time, including Cliff Leslie, H. S. Foxwell, Henry Sidgwick, and F. Y. Edgeworth. In 1881 Jevons wrote to Walras: " I am glad to say I think the Math. View of Economics is making much progress in England and is fully recognized by those competent to judge." Jevons was sure that he would revolutionize the science of economics, but he did not serious students left after him. However, Jevons's utilitarian calculus had influence on Marshall' development.

In August 1882, having disobeyed his doctor's orders not to swim, Jevons drowned off the coast of Devon. Jevons was a good swimmer but the water in Devon happened to be much colder that year and shock most likely induced a heart attack. Although he had plans several books, it is unclear if he would have been able to complete them. According to his wife, "his health was an increasing anxiety and his mind so encumbered with all he wanted to do that he seemed to feel life grow more and more hard to him every year."

3. MATHEMATICAL THEORY OF ECONOMICS

Jevons' main contributions to theoretical economics, - theory of value, theory of exchange, and theory of labor and capital, - are to be found in his *Theory of Political Economy*. Indeed, others had developed many of his

economic theory before. For example, Dionysius Lardner, who developed a theory of the firm in his "*Railway Economy*" of 1850, and Fleeming Jenkin, who constructed a graphical presentation of the law of supply and demand in 1870. Nevertheless, many of Jevons's theoretical contributions were original and his great idea. The idea that the origin of the objective exchange values of the market was to be traced to the subjective valuations of individuals, very revolutionary. Moreover, according to L. Robbins Jevons's idea emphasized the analytical tradition in economics. Robbins pointed three aspects of this shift of emphasis in his article "*The Place of Jevons in the History of Economic Thought.*"

First, modern economist (neo-classical) put individual-the economics subject- in the center of the analytical picture. Mercantilists were preoccupied with gold, and the classical with goods. Although classical economists regarded goods as having value with possessing utility, they tended to take the demand side unimportant and never attempted to go behind demand to the more fundamental subjective valuations. They moved all time in the world of goods without inquiring concerning their significance to the individual. The subjective theory of value changed all that. In the second place, because of the subject theory of value changed all goods that are limited in relation to demand, are economic goods and have value. Last aspect of emphasis was mutual determination. Classical economists did not recognize the influence of demand on the prices of factors of production. [L. Robbins (1936) p. page #5-6].

3.1. The Theory of Value:

Jevons described his theory as the mechanics of utility and self-interest, and argued that "a true theory of economy can only be attained by going back to great springs of human actions-the feelings of pleasure and pain." He had early and unbounded faith in the future of mathematics and statistics as indispensable aids to discovery of quantitative analysis of the feelings of pleasure and pain. Of the seven Benthamite "circumstances" associated pleasure and pain, Jevons selected (1) intensity, (2) duration, (3) certainty or uncertainty, and (4) nearness or remoteness. Jevons discussed each of these at length. Jevons chose intensity and duration as the dimensions of feeling, particularly at the exclusion of certainty and propinquity which, have just as much bearing on the notion of feeling. He intent on constructing an algebraic function that could give the quantity of feeling for any had given time interval. Moreover, a positive or negative sign can be ascribed to particular feeling depending on whether it is pleasure or painful. In this way, feelings can be added to or subtracted from another, with the goal of having pleasure as the net result.

Jevons defined a commodity as an "object, substance, action, or service, which can afford pleasure or ward off pain," and "whatever can produce pleasure or prevent pain may possess utility." Thus a commodity is objectively determined, utility can only be ascertained subjectively, by "the

will or inclination of the person immediately concerned." Identical objects can have varying amounts of utility for different persons and even for one person, depending on the time and place. For example, A quarter of water does not have an inherent amount of utility. The utility of any one-quart depends upon the availability of other quarts and number of quarts already consumed in recent past. To person in desert, a an initial quart or event a sixth quart may possess infinity utility, whereas to a person in city, with readily available sources close at hand, a quart of water may have a utility close to zero. In the case of flood, a quarter of water clearly has negative utility or disutility. Jevons specified that a utility function is a relation between the commodities an individual consumes and an act of individual valuation. Therefore, utility is not a sum of an intrinsic or inherent quality that thing possesses. Instead, utility has meaning only in the act of valuation.

Jevons considered that the utility theory was fundamental theory of pleasure and pain. The classical economists had long recognized utility as necessary but not sufficient condition for an object to qualify as a commodity. However, they had not attempted to ground this in the Bentham's pleasure –pain calculus. Robert B. Ekelund, Jr. and Robert F. Hebert have stated that "Jevons's improvements over Bentham's performance consist in following features of his formal utility analysis: (1) his clear distinction between total utility and marginal utility, (2) his discussion of nature of marginal utility, and (3) his establishment of the equimarginal principle, as it relates alternative uses of the same commodity and to choices between commodities." in their studies, "*A History of Economic Theory and Method*." [R. B. Ekelund, Jr. and R. F. Hebert (1997) p. page #324].

Graphical Analysis: Jevons followed the practice of all mathematical economists of assuming perfect divisibility of commodities. Therefore, his utility function is expressed as a U = f (X) and it state that the utility of commodity X is a function of the quantity of X the individual holds. Assuming that one could add tiny portions of food to individual's store, one might derive a utility function as shown in figure 1 part a. Here the total utility of goods X (the quantities of other things held constant) may be seen to rise as quantities are added up to $X_{0,}$ reach a maximum at that point, and decline.

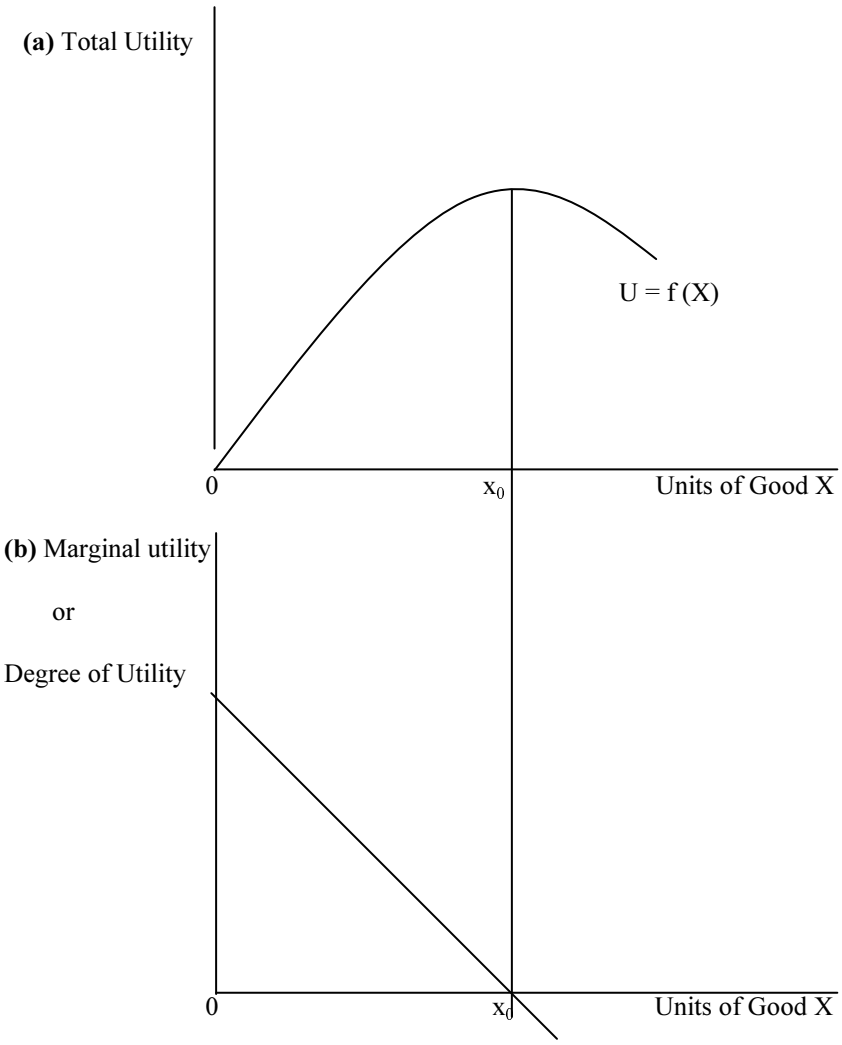

Figure 1[1]**.** Total utility rises continuously up to x_0 units of good X, but marginal utility declines continuously as additional units of good X consumed per unit of time.

However, the utility of an additional unit of goods X, which Jevons called the "degree of utility," declines as units of goods X are added to individual's consumption. Jevons defined the " degree of utility" in mathematical terms and wrote du/dx, to be read as "the ratio of small change in utility to a small change in goods X." Figure 1-b, which is derived from figure 1-a, demonstrates this idea. From the assumption that " all our

[1] Figure adapted from "*A History of Economic Theory and Method*." [R. B. Ekelund, Jr. and R. F. Hebert (1997) p. page #325].

appetites are capable of satisfaction or satiety sooner or later," Jevons states a "general law" today known as the principle of diminishing marginal utility: "the degree of utility varies with the quantity of commodity, and ultimately decreases as that quantity increases." Thus, total utility is not the relevant concept. Rather, degree of utility, or, to be even more precise, the "final degree of utility" is the concept theory of economics.

Using this idea of the final degree of utility, Jevons considers the problem of distributing a good, for example barley, among alternative uses, such as beer, bread, and cattle feed. The most satisfactory distribution of the barley is one where no further redistribution would yield additional utility. This implies that the final that degrees utility for each of the two or more uses to which the barley is put equal. The principle is presented in algebraic terms. If barley, s, can used for either beer, x, or bread, y, and s = x + y, then the most efficient distribution is one where

$$\mathbf{du/dx = du/dy} \quad \text{or} \quad \mathbf{MU_x = MU_y}$$

Where MU_x stands for the degree of utility of commodity X in used x, and similarly for y. Jevons acknowledged the fact that this equation fails to hold in cases where it would be more advantageous to apply the good exclusively to one use.

This principle also holds for allocation of scarce, fixed (say, income) among all goods in the individual consumer's budget. If x represent beer and y represent bread, then the consumer will allocate scarce income s such that the $\mathbf{MU_x = MU_y}$ **,** assuming the beer and bread are the same price and that all s is expended on these two goods. Although Jevons did not work the details, his statement underlies the whole development of his theory of individual maximization behavior, which is at the core of contemporary theory. However, economic theory in period 1870-1914 consisted almost wholly of static microeconomics based squarely on the equal-marginal rule.

3.2 The Theory of Exchange:

Jevons developed a theory of exchange that is an explanation of why and how goods trade between individuals in the market. He started by constructing a market and trading body. By a trading body Jevons meant "any body of either buyer or seller," which runs the range from individuals to an entire population and these individual or group of individuals engaged in exchange. Jevons also noted two other important assumptions, the classical postulates of self-interest and perfect competition. "Every individual must be considered as exchanging from a pure regard to his own requirements or private interests, and there must be perfectly free competition, so that any one will exchange with any one else for the slightest apparent advantage." Both of these assumptions play an essential role in his theory of exchange.

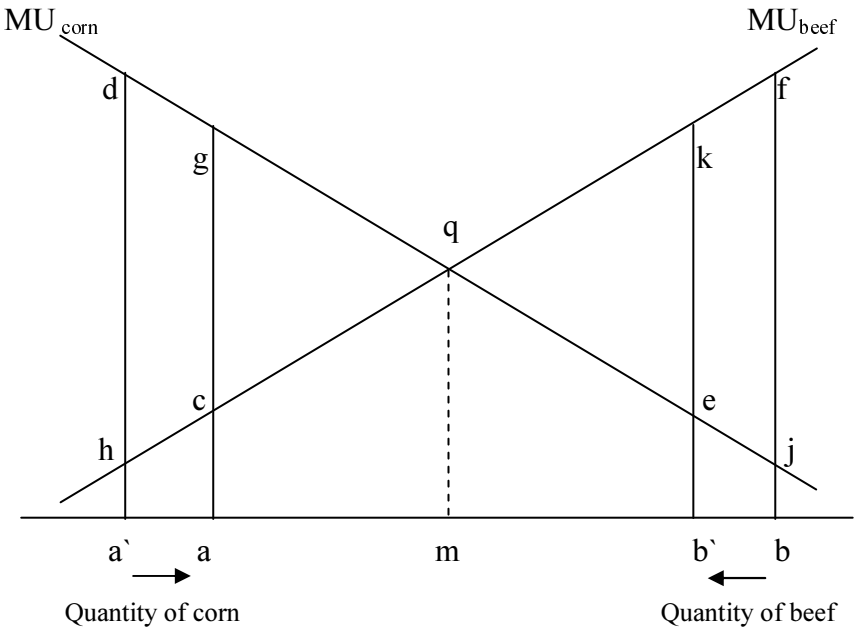

Figure 2[2]. At all points to the left of m, A receives a net gain in utility by exchanging beef for corn, whereas at all points to right of m, B receives a net gain of utility by exchanging corn for beef.

Jevons next assumption was the "Law of Indifference". The law state that " in the same open market, at any one moment, there cannot be two prices for the same kind of article." This law permitted him to derive an important mathematical relationship that he thought he needed in order to solve the exchange equations. If two identical goods command the same unit price, if a trader is completely indifferent between one portion of stock and another, then "the last increments in an act of exchange must be exchanged in the same ratio as the whole quantities exchanged." In mathematical terms, this is expressed as : $dy/dx = y/x$, where x and y are quantities of commodities such that "more or less can be given or received in infinitely small quantities."

To analyze exchange, Jevons took two trading bodies, that one (A) possessing a stock of beef (a) and another (B) possessing a stock of corn (b). Let the marginal-utility functions for corn and beef be represented as in figure 2. And let an increase (decrease) in the quantity of corn (beef) be read from left to right on figure 2 and an increase (decrease) in the quantity of beef

[2] Figure adapted from "*A History of Economic Theory and Method*." [R. B. Ekelund, Jr. and R. F. Hebert (1997) p. page #325]

(corn) be read from right to left in same figure. It noted that equal lengths must represent units of both commodities.

Consider trading body A and assume that it holds a quantity a` of corn. An increase in A's holding of corn, represented by the little line a`a, simultaneously represents a decrease in A's holdings of beef. However, important point is that A gains by trading of beef for corn. Because it would gain more utility by acquiring corn i.e., a`dga than it would lose by giving up beef i.e., a`hca. With figure 1, A would gain a net gain of area hdgc. So that exchange ceases when the degrees of utility of the portion given and the portion received are, for each trader, equal in their own respective mind. The intersection of the marginal-utility curves, at m, is equilibrium point. Because no further gains from trade can be realized by either trading body, and trade end.

Jevons also expressed the condition in algebraic term. If assume MU_a^A represent the final degree of utility of commodity a (corn) and so on, then Jevons's equilibrium equations of exchange may be expressed as;

$$\mathbf{(MU_a^A / MU_b^A) = (MU_a^B / MU_b^B) = (b/a)}$$

One important consequence of the theory of exchange is that a person distributes his income in such a way as to equalize the utility of final increments of all commodities consumed. Since exchange only occurs when a net increase in utility results, all commodities are distributed by exchange so as produce the maximum benefit.

3.3 The Theory of Labor:

Jevons' theory of labor supply is his most important contribution to the main stream of neoclassical economics. He had done away with classical distinction between "productive" and "unproductive" labor. In his view, any labor, whether it is bricklaying or balletdancing, insofar as it yield utility to the consumer, is productive. However, he believed that labor differences was in quality and efficiency. So that, wages correspond to the final productiveness of labor inputs. He stated this view in his masterpiece, "*Theory of Political Economy",* " I assume, as obviously true, that the abilities of men are infinitely varied, whether by nature or by education, so that both the same persons may vary in respect of the same object. This, indeed, is in direct opposition to the erroneous simplification of science effected by Ricardo, when he assumed that all labourers have certain uniform power." [W.S. Jevons, (1871) p. page # 165-66].

Jevons took the theory of Labor supply as an application of utility theory. He defined labor in term of negative utility, as " any painful exertion of mind or body undergone partly or wholly with a view to future good." It therefore same dimensions as utility, namely duration and intensity. Jevons

determined the labor in the concept of net pain or disutility. Therefore, he argued that labor would be supplied as long as the individual contemplates a preponderance of satisfaction over dissatisfaction. He attempted to solve this maxima-minima problem geometrically.

In analyzing to work decision, Jevons focused up on three quantities; net pain from work, amount of production, and amount of utility gained. Geometrically, these three quantities shown in figure 3. On the assumption that the disutility of labor first decreases and then increases with the duration of effort, while the marginal utility of product falls monotonically. That illustrated in figure-3 as the upper curve (pq-curve) expresses the decreasing final utility of the product on the supposition that the product increment is due solely to additional labor. In the other word, it is the reward for labor. The lower curve (ed-curve) shows the disutility of labor per units of product. It is the costs of labor. Jevons assumed that the act of beginning work is onerous and produces net pain. However, as work continues, it becomes increasingly pleasurable on balance, until a point is reached where painfulness begins to overwhelm the pleasure of work[3]. Thus the net-pain-of-labor curve peaks out and turns downward, becoming negative.

The point at which labor ceases is at **m** (where qm = dm), the point at which, for a single person, the net pain of working (md) is equivalent to degree of utility of real wages (mq) produced. To go beyond this point would bring greater costs than rewards. Thus, Jevons established a theory of labor supply based upon his notions concerning utility. Beyond this explanation, Margaret Schabas stated that " The solution offered is misguided. The relevant components are not the lengths qm and dm, but the slopes of the two curve." in her book, *" A World Ruled by Number*". [M. Schabas (1990) p. page # 151].

[3] I think that this curve can be evaluate in long run, as a Adam Smith labor division and productivity relations; specialization increases production. If specialization and production are replace with pain and pleasure, at the beginning of period pain is higher than pleasure. (Less specialization low production, but specialization is costly for worker.) Then increased production, depend upon specialization, will compensate the cost of specialization or pain and then, net gain will be positive.

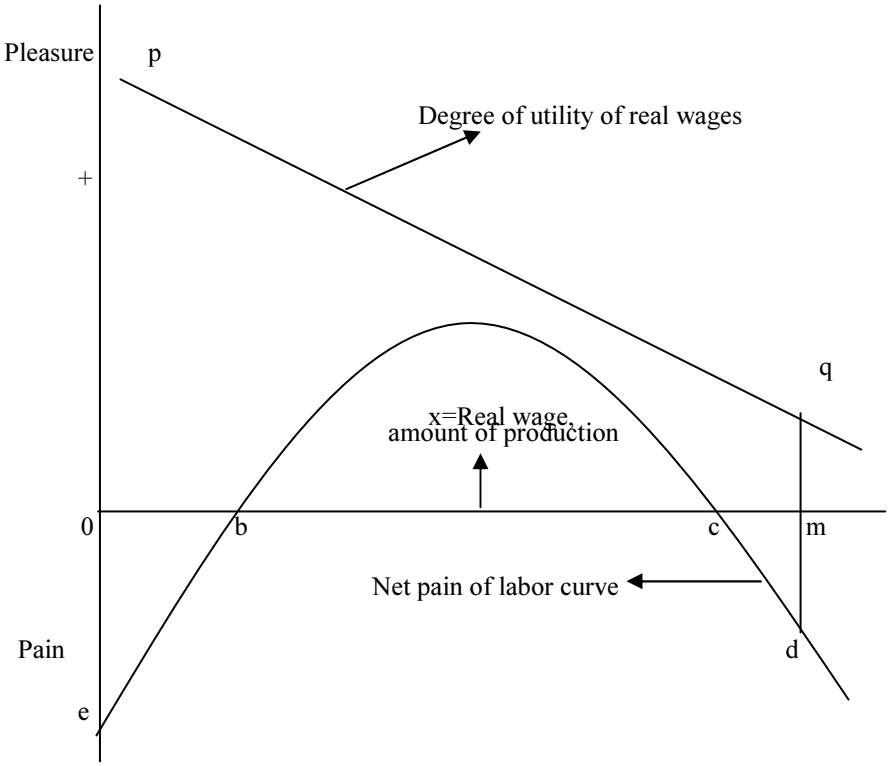

Figure 3[4]**.** In this analysis based on hedonic calculus, a worker will offer labor services in amount **0m**, because at that point the cost of working, **md**, equals the reward of work, **mq** .

Up to this, point Jevons was discussing the theory of labor supply, with setting that labor could never be the cause of value. However, despite the fact that he stated that conflict with his claim that value was determined by utility. It is well-known Jevons' catena:

Cost of production determines supply,

Supply determines final degree of utility,

Final degree of utility determines value.

This chain of causation follows that the cost of production also determines value. Utility or value of the product determines the labor value

[4] Figure adapted from "*A History of Economic Theory and Method*." [R. B. Ekelund, Jr. and R. F. Hebert (1997) p. page #325]

and not vice versa. Independent alterations in supply due to alterations in costs of productive inputs are not taken into account. Supply of goods, as in the theory of exchange shown in figure 1, is presumed fixed.

3.4 Theory of Capital:

Jevons's theory of capital was another important contributions to modern economics. He was one of the first to emphasize the fact that capital is essentially time, the means of lengthening the period of investment. He started from assumption of perfect foresight, and added to these assumptions of preference for present consumption and perfect competition. On this basis, he demonstrated that the rate of interest is equal to marginal productivity of lengthening the period of production. This rate is a "natural rate", "the rate of increase of produce divided by whole produce." He showed that investment is a quantity of two dimensions, the amount of investment and the period for which the amount is invested. Jevons made the important distinction between "free" and "invested" capital, pointing out that the dividing line was far from being definite or rigid. Indeed, most of fundamental idea of contemporary capital theory can found in his work on the subject.

3.5 Statistical Science and Sunspot Theory of Economic Cycle:

Jevons believed that economics used the same inductive method as the physical science. Probability was the necessary basis for the judgments in the science because certainty was unattainable. Therefore, Jevons' conception of probability and of its role in science was expounded in his book, The Principles of Science. The Principles was almost wholly concerned with the physical sciences and questioned the role of probability in the analysis of social data. His inspiration of statistic carried him to the most ridiculed idea of his life, the explanation of commercial crises on basis of the periodic alteration of spots on the sun. In "The Solar Period and the Price of Corn" (1875), Jevons analyzed price data on seven type of grain in search of eleven year cycle. He also calculated from means for each commodity an "aggregate price" the fluctuation in which was " of so very considerable an amount, and so well marked in form, that it might be deemed quite conclusive..". He analyzed the data from another point of view, considering the distribution of the years of maximum and minimum prices through the eleven years of cycle.

In spite of the " sunspot theory" Jevons's overall statistical work deserves very high mark. John Aldrich described the Jevons's statistical works was a painstaking statistical craftsman and states that " When summarizing Jevons's efforts to apply probability to economics, "bright" and "thin" are the adjectives that spring to mind. He was very keen to apply probability in statistical work but he was not able to overcome the difficulties…. Jevons was the applied economist who worked at limit of his understanding of the techniques." in his article, *" Jevons As Statistician: The Role of Probability*". [J. Aldrich (1987) p. page # 251- 253].

4. CONCLUSION

It is true that Menger and Walras covered much the same ground as Jevons. However, If we look only at Britain, a strong case can be made for a "Jevonian Revolution." Until Jevons, Britain economic thought from Lock to Mill formed one long unbroken tradition. He encouraged the new economic analysis and ideas in England and elsewhere. In this respects Jevons' work was superior to that of Menger and Walras. Perhaps if Jevons had never lived, it would have meant only that English economics would have made slower progress. Therefore, it may be right to acclaim Jevons as "The Founder of Modern Economics."

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