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WILLIAM S. VICKREY

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A Biographical Memoir by

JACQUES H. DRÈZE

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WILLIAM VICKREY DIED on October 11, 1996, three days after the announcement that the 1996 Bank of Sweden prize in economic sciences in memory of Alfred Nobel was being awarded to him and to Professor James Mirrlees of Cambridge "for their fundamental contributions to the economic theory of incentives under asymmetric information." Vickrey was eighty-two years old and had been a member of the National Academy of Sciences since April 1996. The press release from the Royal Swedish Academy of Sciences refers specifically to his work in the mid-forties on income taxation, then in the early sixties on auctions. With characteristic independence, Vickrey reacted by privileging instead his work of the late thirties on cumulative averaging of income for tax purposes and his then current concern with unemployment. Early insights, lifetime dedication, and late recognition are unmistakable traits of a truly remarkable career devoted to economics in the service of the public sector.

William Vickrey was born in 1914 in Victoria, British Columbia (Canada). He attended Yale, obtaining a science B.S. degree in 1935 and then went to Columbia University for graduate work in economics, obtaining an M.A. in 1937.

The Ph.D. degree was awarded there in 1947 after completion of the "Agenda for Progressive Taxation," his 496-page doctoral dissertation included in 1972 among the *Reprints of Economic Classics*. The intervening ten years, including World War II, had been spent in various research or advisory positions related to taxation.

Vickrey joined the faculty of Columbia University in 1946 and never left, except for a few sabbaticals. His working life was devoted mostly to teaching and research, but it also included a significant amount of advisory and consulting services on behalf of public institutions and utilities, and a fair amount of non-specialist writing and lecturing.

The advisory and consulting missions encompass the major areas of Vickrey's applied research: taxation, public utilities, transportation, and urban problems. In 1949 he and his Columbia colleague Carl Shoup laid the foundation for the postwar tax structure of Japan. This was followed by a number of tax missions, notably to Puerto Rico, Venezuela, and Liberia. Vickrey also spent a year as an adviser on fiscal matters for the United Nations, working in Singapore, Malaysia, Iran, Zambia, Ivory Coast, Libya, and Surinam.

The work on public utilities started with the electric power industry in 1939 and gained momentum in 1951 with the famous study of subway fares performed for the Mayor's Committee for Management Survey of the City of New York. In 1959 he studied traffic congestion in Washington. Further studies on urban planning and transportation took him to India,[1] Argentina, and Venezuela. Over the years, he developed ideas for efficient pricing of electricity, telephone services, urban transportation, street and road use, municipal services, and airlines. He also kept up with every conceivable technological development in these areas, visiting experimental designs on-site and attending specialized conferences.

The quest for efficiency of public services made him a crusader, advocating innovations not only through lectures for the National Tax Association, the NBER, public utility conferences, and transportation symposia, but also through testimony at hearings and letters to the *New York Times*. Often there is an expression of impatience at the slow acceptance of new ideas by regulatory and operating agencies.[2] In recent years this impatience with blatant inefficiencies has been focused on the macroeconomic field. But the crusade goes on. Irrational budget accounting, excessive concern with inflation, and insufficient attention to wasteful unemployment had become favorite themes on which Vickrey hoped to capture more attention because of the notoriety of the Nobel award.

Response to practical challenges is only one facet of our late friend's intellectual curiosity. His interest in ethics and philosophy led to several publications. Interdisciplinary contacts always appealed to him, in particular through seminars. Bill Vickrey's fearsome participation in seminars was part of his legend, and in particular earned him the Rip van Winkle award from the Center for Advanced Study in the Behavioral Sciences "for deep and uninterrupted concentration while attending seminars."[3] At Columbia, he showed up at seminars in many fields, and invariably attended the interdisciplinary ones.

Vickrey was a distinguished fellow of the American Economic Association (president, 1992) and a fellow of the Econometric Society. He was a past president of the Metropolitan Economic Association and the Atlantic Economic Association. Among various honors he received were the F. E. Seidman Distinguished Award in Political Economy and a doctor of humane letters degree from the University of Chicago.

William Vickrey's career was exceptionally rich, having

extended over a full sixty years. His work included highly original contributions over a broad spectrum and displayed some distinctive methodological traits. His publications included eight books and some 140 articles, of which a selection with introductory reviews was published in 1994 by Cambridge University Press under the title *Public Economics*. The following illustrates the originality with reference to incentives and information, suggests the spectrum in regard to public economics, and concludes on methodological traits.

INCENTIVES AND INFORMATION

A central concern of economics is the extent to which decentralized decisions by a myriad of economic agents (consumers, workers, producers, asset holders, and public authorities) are compatible with efficiency and equity. Efficiency is a property of economic situations where it would not be possible to improve any one individual's circumstances without impairing those of another; in short, there is no waste. Equity is a more demanding and more controversial property; it relates the distribution of benefits across individuals to ethical premises.

Efficiency of decentralized decisions becomes possible when individual decisions are based on information and incentives reflecting correctly common values. In relatively simple situations, competitive prices for commodities (goods and services) provide correct information and incentives, as was recognized in 1776 by Adam Smith in *The Wealth of Nations*:[4] the marginal relative values of commodities are the same for all, since all face the same prices (information), which they cannot manipulate (incentives); further exchanges could not benefit both parties.

The "simple" situations correspond to a surprisingly broad range of economic activities, yet fall substantially short of

universality. For instance, public services, like transportation and utilities, are produced under scale economies, which suggest a single producer (monopoly). Decreasing marginal costs lead to losses under competitive pricing. Either prices are not competitive or losses are covered by taxes and transfers. But taxes distort relative prices and affect incentives. Also, taxation raises at once equity issues.

In 1938 Carl Shoup, professor of public finance at Columbia University, and his research assistant Vickrey were discussing methods of taxing capital gains (i.e., wealth increments due to appreciation of assets, such as houses and shares of stock):

> The idea emerged that ideally, at least, the method of taxation should be such that the tax should be completely neutral with respect to the time at which a gain is realized (i.e., that the tax payer should have no incentive in the long run for preferring to realize at one time rather than another on account of the tax). From this it was a short step to requiring neutrality with respect to the time of realization or reporting of all forms of income. It then remained only to work out the implications of this requirement for the formulation of the tax, and to devise procedures for the assessment of the tax that would be administratively feasible (1972).

The procedure devised by Vickrey, cumulative averaging, is quite simple once you think about it. It considers "all payments of income tax, with respect to income reported since some base starting date, as interest-bearing deposits in a taxpayer's account with the treasury. The accumulated balance on this account would then be available as a credit against whatever tax is found to be due for the entire period to date, on the basis of the total income thus far reported for the period . . . inclusive of the interest credited on the tax deposit account (which is, in effect, to be treated no differently from interest earned on any other type of deposit)" (1972). This simple scheme would achieve the required neutrality with respect to the time at which a gain

is realized, that is, the tax system would become incentive-compatible with efficient economic decisions.

Cumulative averaging has not been applied on a significant scale, for the same reason perhaps that major revisions or simplifications of the income tax, whatever their nature, do not come into being. Still, the merits stand: neutrality, equity with regard to fluctuations and sources of income, simplification of the tax law, and elimination of loopholes.

A few years later, Vickrey was concerned with the proper graduation of progressive taxation. He investigated the prospect for implementing the so-called utilitarian approach outlined by Francis Edgeworth in 1897.[5] Assume that the benefits of a higher real income could be measured by a function of income, labeled utility. Edgeworth posed the problem of income taxation as that of maximizing, through taxes and transfers, the total utility derived by a population from a given fixed aggregate income. Vickrey's contribution was twofold. First, he sought a way of defining and measuring utility that would be germane to the problem. Second, he recognized that income tax distorts incentives to earn income, so that the aggregate income cannot be treated as given and fixed.

The first contribution consisted of adopting the method of representing choices among risky alternatives by comparisons of expected utilities, a method introduced in the eighteenth century by Daniel Bernoulli[6] and axiomatized in 1945 by John von Neumann and Oskar Morgenstern in their *Theory of Games and Economic Behaviour*.[7] If a person is indifferent between an income prospect of $50,000 and a fifty-fifty chance of either $20,000 or $100,000, the utility difference between 50,000 and 20,000 is set equal to the utility difference between 100,000 and 50,000. Vickrey recognized as follows the relevance of this construction to the Edgeworth problem: "If utility is defined as that quantity

the mathematical expectation of which is maximized by an individual making choices involving risk, then to maximize the aggregate of such utility over the population is equivalent to choosing that distribution of income which such an individual would select were he asked which of various variants of the economy he would like to become a member of, assuming that once he selects a given economy with a given distribution of income he has an equal chance of landing in the shoes of each member of it" (1945). The gedanken-experiment introduced by Vickrey is the basis of modern utilitarianism, an important branch of contemporary social choice theory. It is also used, under the name of "original position, behind the veil of ignorance" in *Theory of Justice*[8] by John Rawls.

The second contribution is well described by the Swedish Academy:

> Vickrey's analysis emphasized that a progressive tax schedule would affect individuals' incentives to exert themselves. He therefore reformulated the problem with respect to both incentive problems—that each individual takes the tax schedule into account when choosing his work effort—and asymmetric information, that in practice, the productivity of individuals is not known to the government.[9]

Vickrey formulated the mathematical problem associated with optimal taxation and derived an appropriate Euler equation, but he went no further, and left it to James Mirrlees to give an explicit characterization twenty-five years later.

The Swedish Academy emphasized the link thus established between incentives and information. It stressed the role of that link in lively developments of contemporary economic research and also related it to Vickrey's work on auctions.

> Asymmetric information is also an essential component of auctions, where potential buyers have limited knowledge about the value of the asset or

rights up for sale. Vickrey analyzed the properties of different kinds of auctions in two papers in 1961 and 1962. He attached particular importance to the second-price auction or, as it is now often called, the Vickrey auction. In such an auction, an object is auctioned off in sealed bidding, where the highest bidder gets to buy the item, but only pays the next highest price offered. This is an example of a mechanism which elicits an individual's true willingness to pay. By bidding above his own willingness to pay, an individual runs the risk that someone else will bid likewise, and he is forced to buy the object at a loss. And vice-versa, if an individual bids below his own willingness to pay, he runs the risk of someone else buying the item at a lower price than the amount he himself is willing to pay. Therefore, in this kind of auction, it is in the individual's best interest to state a truthful bid. The auction is also socially efficient. The object goes to the person with the highest willingness to pay, and the person in question pays the social opportunity cost which is the second highest bid. Other researchers have later developed analogous principles, for example in order to elicit the true willingness to pay for public projects. Thus, Vickrey's analysis has not only been momentous for the theory of auctions; it has also conveyed fundamental insights into the design of resource allocation mechanisms aimed at providing socially desirable incentives.[10]

Recent years have witnessed spectacular application of auctions theory, in particular to bidding for band spectrum licenses.[11] It is surprising that, to the very end, Vickrey would label this work "one of my digressions into abstract economics, at best of minor significance in terms of human welfare."[12]

PUBLIC ECONOMICS

Concern about human welfare pervades the sixty years of Vickrey's professional life. Considered in retrospect, with the benefit of hindsight, his numerous and widely scattered contributions come close to retracing the history of the field of public economics as it evolved over the last forty years.[13] The field is concerned with the economics of the public sector, with government's effect on the economy. It is today a broad field, where microeconomic theory is ap-

plied on the one hand to the revenue side, in particular taxation; and on the other hand to the sphere of real activities carried out or regulated by the public sector. It is a difficult, complex field. On the revenue side, efficiency calls for second best analysis (i.e., minimizing the dead-weight burden of taxation), whereas equity goes straight to the ethical roots of social choice theory. On the real side, if public intervention makes sense, there must be a reason why the market mechanism is not fully operative—like externalities, non-convexities, or information asymmetries. The challenge is thus to invent mechanisms that somehow succeed where the market fails—a challenge that is never trivial.

Reference has been made above to William Vickrey's seminal role in the emergence of modern utilitarianism. Shortly thereafter, he had the good fortune of supervising Kenneth Arrow's doctoral dissertation "Social Choices and Individual Values."[14] Vickrey himself devoted several papers to the area. As early as 1960, he discussed in that context strategic misrepresentation of preferences, a topic that figures prominently in the work on auctions and in an extensive literature on demand-revealing mechanisms.

Reference has also been made to cumulative averaging, Vickrey's "proudest accomplishment" in the area of taxation. It was, however, only one out of twenty-one specific recommendations listed in the *Agenda for Progressive Taxation* (1947). One particularly innovative chapter deals with inheritance taxes, resting again on a neutrality principle (1944). In the ensuing years, the tax treatments of corporate income, government interest, land values, and charitable contributions retained Vickrey's attention. An overall evaluation of these contributions is worded as follows by Anthony Atkinson, a leading British specialist: "Bill Vickrey occupies a unique position among public finance economists. His contributions to taxation, simultaneously analyti-

cal and policy-relevant, are characterized by an inventiveness which is unrivaled. They derive from a powerful, yet essentially simple, view of the logic of taxation, a logic which has quizzed his writing over more than half a century."[15]

On the real side of public economics, Vickrey's work is equally extensive. Much of it derives from his interest in marginal cost pricing, "a device for improving the efficiency with which we use various facilities" (1970). The principle is straightforward in simple situations, for instance, when a specific good or service is consumed at a constant rate over time and produced under conditions of constant or increasing marginal cost. Marginal cost is then well defined and defines in turn the efficient, competitive price. Fluctuations in demand or cost over time and space or in response to imperfectly foreseen circumstances, decreasing marginal costs or heterogeneous production complicate matters. Marginal cost pricing then becomes a subtle art, calling for skillful application of theoretical guidelines. The relevant concept is that of short run marginal social cost (SRMSC) to the proper definition of which Vickrey has contributed several useful precisions. This is not the place to review theoretical intricacies, but it is possible to give a flavor of some of the more innovative applications devised by Vickrey in the areas of public utilities and urban transportation. Here are some illustrations, listed in chronological order to bring out the extent to which they anticipated current developments.

In 1948 Vickrey was concerned with the assessment of SRMSC over time, when the demand for a service at a given future date is imperfectly predicted by the seller, but is known to some buyers apt to make advance reservations. Seats on long-distance flights or rooms at vacation resorts provide examples. He suggested "a fairly elaborate pricing scheme in which the price quoted would vary according to

the proportion of seats on a given flight already sold and the time remaining to departure, in simulation of what an ideal speculator's market might produce, the price at any time being an estimate of the price, which, if maintained thereafter, would result in all the remaining seats being just sold out at departure time" (1948). Today, some airlines and tour operators follow precisely this advice, using a technique known as yield management, for which elaborate software is produced commercially.

In 1950-51 Vickrey was consulting for the Mayor's Committee for Management Survey of the City of New York. He was assigned the problem of subway fares, with the aim of reducing the drain of the transit deficit on the city's finances. Evaluation of the SRMSC led him to suggest replacing the prevailing 15-cent flat fare with an efficient set of fares varying from 5 cents to 25 cents according to time of day and trip definition (origin and destination). He even designed a new electromechanical turnstile permitting automatic implementation. Today, such differentiated fares are commonplace in many cities, with implementation facilitated by magnetic cards and electronic processing.

Subways operate under marginal costs that decrease with overall traffic. Pricing at SRMSC entails losses. If budgetary considerations place a ceiling on these losses, a second-best solution calls for raising prices above SRMSC to an extent determined by demand elasticities (and just sufficient to meet the ceiling). That principle had been discovered and translated into mathematical formulae by Frank P. Ramsey in 1927.[16] That contribution had fallen into oblivion, however. Spurred by the practical subway challenge, Vickrey computed the Ramsey solution and extended it in one important respect. Instead of accepting an arbitrary ceiling on the losses, he evaluated the social cost of the distortions associated with revenue raising by the city, summarized in a

marginal cost of public funds (MCPF). He then proposed a fare structure such that the marginal inefficiencies associated with reducing the losses matched exactly the MCPF. The subway study stands out as a classic in applied public economics, the reading of which is still instructive today.

In 1959 Vickrey studied road transportation in Washington, D.C., stressing the quantitative importance of the underpricing of rush-hour auto travel. He estimated that, if a suburbanite gave up bus commuting to drive a $3,500 automobile into town, it would cost $23,000 in infrastructure investment to keep road congestion unchanged. The solution was to impose road tolls in amounts corresponding to SRMSC. These tolls would vary with the time of day, culminating at the rush hours. They would help spread the peak and encourage bus travel.

Here again Vickrey faced a technical problem of implementation: toll booths slow down the flow of traffic. He proposed instead the use of vehicle identifiers that could be read electronically without slowing down the traffic and obtained a prototype and cost estimate from a manufacturer. Today, that system has been fully developed, is being used in a few places, and is seen as the way of the future.

Further investigation of the optimal tolls led ten years later to a paper described by specialist Richard Arnott as "almost certainly the most important in urban transport economics over the last quarter century."[17] That paper models the dynamics of rush-hour congestion by treating the departure-time decisions of commuters as endogenous variables. The extended problem is made tractable by modeling congestion as a queue behind a bottleneck. That model has received strong empirical support from detailed traffic flow studies, and has changed the way traffic engineers think about the problem. An interesting property of equilibrium is that it leaves commuters at least as well off as before, so

that the toll revenues come free. Road tolls are an example of responsive pricing (i.e., prices varied from moment to moment in response to observed congestion levels). The concept has been applied repeatedly by Vickrey to public utilities, like telephone and electricity, but also water supply.

In 1963 Vickrey published a first paper on pricing and financing of urban services, such as fire protection, water provision, parks and recreational facilities, and education. Fire protection (which accounted at the time for 8% of all general expenditures by cities) is an interesting illustration. Vickrey noted that a given grade of fire protection is a matter of providing an engine company within a suitable number of minutes of travel time, and concluded that the appropriate charge should be a matter of land area (rather than property value under current practice).

The interest of Vickrey for urban problems spread to other areas, like land value taxation. Here again he extended and clarified the theoretical basis by showing how, in equilibrium, "the aggregate of the land rents generated by the urban agglomeration produced by the existence of activities with economies of scale within the city will equal the subsidies required to enable these activities to sell their output at prices equal to their respective marginal costs" (1977). (This is a modern extension of an approach introduced by Henri George, of which several variants were published in the 1970s.) That result sets the problem of land value taxation and financing of public services in a general equilibrium framework.

STYLE AND METHODS

The review above is partial, as it leaves out altogether Vickrey's interest in macroeconomic stabilization, which became his major concern from the mid-eighties on. It also

leaves out most of his writings about ethics and justice and sundry contributions on such topics as "The Prevention of Gerrymandering" (1961), "Application of Demand Revealing Procedures to International Disputes" (1978), and many more.

The momentous research output of William Vickrey has some distinctive features that give him a very special place among contemporary economists. First, it should be clear from the foregoing that his work combine depth and breadth—depth, by grounding specific research firmly in the theory of economic efficiency (leading, for instance, to a correct definition of SRMSC), as well as in a modern approach to equity and social choice; and breadth in the treatment of a wide range of topics covering the revenue as well as the real side of public economics.

Second, the starting point of Vickrey's investigations is always rooted in real world problems. His interest was to solve the problem at hand. To that end, he brings in general principles, and his proficiency as a theorist pays off. Often he is led to extend the principles into new theory, but he is hardly interested in theory for its own sake—only to the extent that it carries policy implications.

Third, and related, Vickrey was unique among his contemporaries for his determination to carry out theoretical contributions all the way to practical application. This is illustrated already in his work on cumulative averaging, which led him to develop concrete proposals for legislation. Further examples are found in his work on subway fares and road pricing, and there are many more.

Fourth, and again related, there is "a certain characteristic style of understatement and specificity of application in Vickrey's work, which has in some ways helped, in perhaps more ways hindered, the full understanding of his originality."[18] Vickrey's papers contain little or no mathematics. Where

they do, he is apologetic. Intricate reasoning is typically encapsulated in a sentence or two, as exemplified in the four original quotations used above. Important statements like these repeatedly appear as side remarks in the discussion of a specific application. The generality is hardly stressed except through reference to further applications. The modern economic style of proceeding from numbered assumptions to numbered theorems was quite foreign to Vickrey, in spite of his familiarity with, and thorough understanding of, the relevant literature—a refreshing exception, given the richness of content.

There is no doubt that William Vickrey was a powerful theorist, capable of abstraction and conscious of generality. It is also clear that he was eager to communicate. He was not writing for himself, but to be read. He was particularly eager to be understood by policy makers. Relying on the simplicity of basic reasoning and expressing it verbally was for him a natural vehicle of broad communication. Mostly, he was himself. His relative neglect of systematic theoretical construction probably reflected the little need he felt for it, being able to understand quickly principles and their main implications. He could himself dispense with spelling out details, unless directly relevant to his immediate purpose.

Given Vickrey's talent and analytical ability, some of us regret that he did not put more systematic theoretical effort into his favored topics. Given his bend of mind, it is hard to tell how successful that different orientation would have been. Indeed, creative theoretical work is often produced by researchers primarily interested in real-world problems; and imaginative practical solutions often come from gifted theorists. Vickrey's bend of mind was indispensable to bridge the gap between theory and application. And it was probably an efficient division of labor that he would let

others refine the theory, while he himself stayed on the development frontier, demonstrating the fruitfulness of an approach that too few among us are capable of pursuing with excellence.[19]

Ultimately, William Vickrey's forte was originality and creativity, reaching out of the boundaries of standard frameworks to develop a different viewpoint. In so doing, he was saved from esoterism by his uncompromising logic. His style of writing partook of his originality, and may have interacted with the originality of the ideas to explain late recognition, a feature stressed in the citation presenting him as a distinguished fellow of the American Economic Association in 1978:

> Many of us have had the experience of thinking we were the first to show the neutrality of a particular tax scheme, to prove the incentive characteristics of a particular bidding institution, to deduce the redistributive implications of the expected utility hypothesis, to invent a demand revealing process, and so on, only to find that William S. Vickrey had done it earlier—sometimes much earlier—and whereas our "original contribution" may have contained minor or even a substantive error, Vickrey had done it correctly. Some great scholars receive recognition from the beginning, but inscrutably, with others it takes a little longer. His numerous works, appearing in all the leading journals in economics, law, operations research, finance and taxation, contain many seminal contributions, and many more that would have been seminal but for the fact that the profession was not yet ready for his ideas.

NOTES

1. I once heard from an Indian economist that, of all foreign economic advisers, Vickrey had been the most directly helpful, because he had produced new railway schedules that permitted substantial energy saving and improved service.

2. Vickrey's presidential address to the Atlantic Economic Association in October 1992, entitled "My Innovative Failures in Economics," begins as follows: "You are looking at an economist who

has repeatedly failed in achieving his objective, even though achieving considerable esteem among his fellows."

3. I have often heard a younger colleague report: "I went to give a talk at Columbia. There sat that tall white-haired man, asleep with his head against the wall. All of a sudden, without raising an eyelid, he mumbled the most penetrating question, and I wondered for a while whether I still had a paper . . . ."

4. Strahan and Cadell, Glasgow.

5. F. Y. Edgeworth. The pure theory of taxation, III. *Econ. J.* 7(1897):550-71.

6. See D. Bernoulli. Specimen theoriae novae de mensura sortis. *Comment. Acad. Sci. Imp. Petropol.* 5(1738):175-92.

7. Princeton University Press, Princeton.

8. Harvard University Press, Cambridge, Mass., 1971.

9. Cf. *Scand. J. Econ.* 99(1997):175.

10. Cf. *Scan. J. Econ.* 99(1997):177.

11. Cf. J. Macmillan. Selling spectrum rights. *J. Econ. Perspect.* 8(1994):145-62.

12. Quoted by D. O'Flaherty. William Vickrey, 1914-1996. *The Independent.* London, October 13, 1996.

13. See also J. Drèze. Forty years of public economics. *J. Econ. Perspect.* 9(1995):111-30.

14. Wiley and Sons, 1951.

15. Quoted from W. Vickrey. *Public Econ.*, *op. cit.*, p. 101.

16. F. P. Ramsey. A contribution to the theory of taxation. *Econ. J.* 37(1927):47-61.

17. *Public Economics*, op. cit., p. 274.

18. Quoted from K. Arrow in *Public Econ.*, *op. cit.*, p. 13.

19. Quoted from J. H. Drèze. Research and development in public economics: William Vickrey's inventive quest of efficiency. *Scand. J. Econ.* 99(1997):194.

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