A NEO-CLASSICAL ECONOMIC PERSPECTIVE ON URANIUM FOR NUCLEAR POWER*†

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* Review article of **The Economics of Uranium** by Anthony David Owen (Praeger, New York, 1985) pp.xviii + 217, $85 ISBN 0-03-003799-9.

THE ISSUES ADDRESSED

This book is concerned with the *commercial* use of uranium to generate electricity, rather than with the military applications of the element. It is argued that ". . .the fortunes of the uranium industry are presently contained within the *economic* viability of nuclear power vis-a-vis its oil and coal fired competitors. . ." (p.4, emphasis added). Owen acknowledges that his discussion of the uranium industry is "fairly narrow" and that the environmental, social and political controversies associated with uranium are hardly addressed. He points out that this emphasis does not reflect his own opinion on the relative merits of these issues: such an analysis is a study in its own right. I will return to consider Owen's perspective on this matter subsequently.

Owen gives a brief 'historical background' of the discovery of uranium and radioactivity and their major 'use', i.e., atomic weapons, that is sufficient for the purpose of the book.[1] He then devotes a whole chapter to an explanation of the *commercial* nuclear fuel cycle emphasising the components of nuclear reactors, the various alternative technologies (light water reactors, gas-cooled reactors etc.), the stages of the fuel cycle (mining and milling, refining and conversion, enrichment etc.) and the *commercial* costs of using nuclear fuel at the various stages of the cycle. He makes it clear (p.5-6) that in the time perspective of his study, *viz,* 20 years, he is assuming no radical change in available technology in the electricity generating industry.

His next chapter 'History of the Uranium Market' is fascinating. It is clear from the first paragraph that this is not a 'normal market' in the economic sense of that term: the acts of governments, particularly that of the United States (US), are dominant in determining prices and

† I acknowledge with thanks the assistance of Professor H.M. Kolsen. Some of the arguments presented here have been developed in long discussions between us, and some of the points made here are, I think, his. The advice of Dr R. Gwyther is also acknowledged. Needless to say, the usual *caveat* applies.

output, as well as bringing the 'market' into existence. His discussion of this 'market' is segmented in time from the Manhattan Project to 1968, the year in which a "commercial market was established in the United States" (p.37), and the period after 1968. In the first period the significance of government is all pervasive: "During the 1950s prices were maintained at a level designed to encourage the rapid expansion of the uranium-mining industry to enable the United States and the United Kingdom to establish adequate nuclear arsenals and strategic stockpiles. Following the end of the Cold War, stockpiling, stretchout programs, and the growth of demand from power utilities, combined with an embargo on uranium imports, sheltered US producers from the uneconomic prices which competition would have determined." (p.44) The reader is left in no doubt that the industry was not only created, but nurtured by, the nation states. Governmental regulations and subsidies made this industry larger than it would have been without such interference.

Owen's account of the uranium market after 1968 enters more familiar territory. The Arab-Israeli war of 1973, the OPEC oil embargo, rapid price rises of oil and uranium, the activities of the uranium cartel ('The Club') which were revealed by Friends of the Earth in 1976 in Australia from 'acquired' memos and letters from Mary Kathleen Uranium, the Westinghouse Case, and then the slump in prices in the early 1980s, are put in the context of the demand for energy in the industrialised economies.

The next chapter 'World Resources, Reserves and Exploration' provides essentially descriptive material on these issues. Owen classifies the various ore deposits in terms of cost of recovery, thus putting the issues in an economic framework. The chapter 'World Uranium Production' is also descriptive, with various projections of future production. Eight countries produce 98 per cent of uranium in the west and this chapter provides a wealth of detail (geographic location of deposits, ownership of deposits, estimated reserves, planned production, etc.), on each country. There are virtually no data available on the uranium industry in the centrally planned Eastern European countries, the Soviet Union and China. In the 1980s, the industry is characterised by 'an excessive level of inventories' (in the US private and government inventories amounted to nine years' forward consumption in 1982!), surplus production capacity and depressed prices. Owen argues convincingly that these circumstances have arisen from optimistic projections of electricity requirements, delays in construction and licencing of nuclear plants (particularly following Three Mile Island in 1979), cancellations of nuclear plants and the economic recession. Since 1979 there have been no new orders for nuclear plants in the US; in addition numerous existing orders have been cancelled and the construction of partly built

plants has been halted. West Germany has not ordered a new plant since 1975. Such a picture is not true of other countries such as France and Japan. Owen emphasises the marked contrast between the reality of the nuclear power and uranium industries and the various future projections of those industries by various industry groups and governments.

Owen's substantive contribution lies in his chapters 'The Demand for Uranium', 'Uranium Price Formation' and 'An Economic Model of the US Uranium Market'. His chapter 'The Economics of Uranium Enrichment' also contains some interesting analysis emphasising once again the important role of government assistance.[2]

The uranium industry is characterised by two prices for the product: 'contract prices' refer to prices determined when a contract is signed, and 'market prices' which are based on prevailing market conditions. The market price can be regarded as a spot, or short-term price. The short-term market accounts for 10-15 per cent of uranium transactions, the remainder being transacted under long-term contracts. Not surprisingly it is the short-term market price that rose dramatically in the 'boom' of mid 1970s and fell equally dramatically in the 'bust' of the early 1980s. Contract prices (in constant prices) have shown a steady rise in the period since 1971. Price volatility in this industry occurs only in the spot market.

Owen is concerned with specifying, and estimating, an econometric model of the US uranium market. His purpose in doing so is to use the model to predict or forecast what will happen to the industry in the future under various scenarios. The equations in the model relate to spot prices, contract prices, consumption (demand), mine production (uranium supply), and forward commitments. The model uses least squares multiple regression analysis on (mainly) data for the period 1966-1982. Owen restricts his forecasts from 1983 to 1990.

Although Owen demonstrates economic sense (e.g., his emphasis on the role of inventories) and econometric skill in estimating the model, his discussion of the results of the various scenarios is brief to the point of leaving the reader wondering what the purpose really was. Although this is his major contribution to our understanding of the industry, his text leaves the impression that he is not all that convinced of its worth. My interpretation of the results of the various scenarios is that spot and contract prices will rise, as will mine production. Thus the current 'bust' in the industry will be over by 1990.

THE MISSING AGENDA

There is nothing in the text to indicate that Owen is anything but a neo-classical economist. This is not meant as a criticism: it is simply an

observation. I find the book, ultimately, to be disappointing, not because of what is done but rather because of what it doesn't do. The major question of public policy with respect to electricity generation is the place of nuclear power in that industry. In terms of this question the issue of the *economic* viability of nuclear power is relevant, not to say central. Owen's discussion of this matter is quite brief and unsatisfactory. As a means of considering this issue, Owen's discussion will be described. The remainder of this review leads to two conclusions, *viz,* a specific criticism of the specification of one of the equations in the econometric model of the US uranium market and second, that the *economic* viability of nuclear power cannot be determined, given the nature of nuclear fission.

Although, as pointed out at the beginning of this review, Owen argues that the future of the uranium industry is intimately connected with the viability of nuclear power compared to the alternative generating technologies, this interdependence is given little emphasis. Owen discusses some Organisation for Economic Cooperation and Development (OECD) studies that purport to demonstrate ". . .that the total cost of nuclear power electricity generation in member countries was significantly lower than that of electricity generation from oil-fired plants while its competitive advantage over coal-fired plants varied from country to country." (p.6) Quite correctly, Owen discusses how this comparison is affected by increasing the interest rate: this has the *effect* of giving coal-fired plants "a substantial cost advantage over nuclear in [the US, Western Europe and Japan]" (p.10). Although Owen is aware of this interdependence of the alternatives (see pp.6-10, 44-51) this interdependence is *not* incorporated into his econometric model of the US industry. The prices of oil and coal seem to be obvious candidates as explanatory variables in his short run uranium price equation. Yet these variables do not rate a mention in his discussion of this equation.

The various OECD studies on this issue are very important: they are used to argue the case for nuclear power by interest groups. The following statement, from an employee of Western Mining Corporation, an indicative: ". . .nuclear electricity has over the past ten years established itself as an effective *economic* competitor in many regions against the principal alternative, coal."[3,4] This author then goes on to assert that, apart from the *economic* advantage, nuclear power has other advantages, *viz,* space requirements, local environmental impact, quality of fuel and quality of waste.

It is crucially important to understand that the various OECD studies, and comments based on them, do *not* relate to economic concepts. Neo-classical welfare economics, since Pigou, has been clear on the matter of the domain of 'economics': economic welfare is ". . .that part of social welfare that can be brought directly or

indirectly into relation with the measuring rod of money.'"[5] This Pigovian concept unambigously established externalities, i.e., unpriced by-products of economic activity, on the economic agenda. *Economic* analysis, then, is concerned not simply with revenues and costs of particular consumers, firms, industries etc., but with all outputs and all costs, irrespective of who receives, or bears, them. The narrow conception is appropriately called 'commercial' or 'financial' analysis: the term 'economic' takes into account outputs and costs 'to whom so ever they may accrue'.

From an economic point of view nuclear fission, which occurs when an atom absorbs a neutron, produces energy, other neutrons and various radioactive isotopes: there are multiple outputs. From a military point of view, the released energy produces destruction of life and property, and the radioactivity from the process produces further destruction of life. A nuclear power plant uses the energy produced by fission to make steam, which is then used to generate electricity. Thus the good, or commodity, produced by fission in a nuclear power plant is energy: this is the commodity which is wanted. The other commodities produced in the process are *not* wanted; but they are inevitably produced at the same time and can be conceived as by-products. However, as there are no markets for these other products, they are externalities, and given that they are *not* beneficial, then they are external diseconomies.[6]

Thus an *economic* study would take these external diseconomies into account by applying 'the measuring rod of money' to them. A study which does not do this cannot be described as 'economic'. Given that some of these external diseconomies have half-lives of 10,000 years it is impossible to give meaningful answers to questions such as 'how much would the community be prepared to pay to producers so that they stopped producing these external diseconomies, i.e., radioactivity?' or 'how much would producers have to pay the community so that radioactivity could be produced?'[7]

There are two reasons that no sensible answers can be given to these questions. First, in the context of nuclear fission 'the community' includes many future generations which will be subject to the radioactivity and which, by definition, cannot be consulted. Second, there is insufficient technical information available on various effects, and containment strategies, for consumers and producers to be able to determine meaningful monetary valuations. The world has only had approximately 40 years experience of the nuclear age and in terms of the half-lives of some isotopes, this experience amounts to very little.

It is correct to say that some costs are incurred by firms in the nuclear fuel cycle for the purpose of radioactive waste management. These costs exist because governments regulate 'safety standards', to various degrees, at the various points in the cycle. Some of these costs

may be included in the various OECD studies. However the discussion in the previous paragraphs does not relate to these costs.

Assume that society takes the view that property rights reside with the members of the community in the matter of production of radioactivity, i.e., that producers have to pay the costs associated with their production of radioactivity. Let us further assume that the members of the community would be indifferent to a situation in which there was no nuclear industry and a situation in which there was a nuclear industry *and* it was impossible for any product containing or contaminated by radioactive nuclides to be released into the environment. These two situations are such that no one is worse off in the matter of exposure to radioactivity. Given this property rights assignment to consumers the producers bear the costs of the waste management strategy. But the point is that, given the state of knowledge on storage of nuclear wastes, these costs are *not* incurred, as it is just not possible to isolate these products from the physical environment *because no one knows how to do it.* Such unknown costs are *not* included in the OECD studies.

It should be noted that this problem does not arise from the existence of the multiple outputs associated with nuclear fission. Multiple outputs are the norm in economic activity. Firms typically produce a range of products, whether they be aircraft or tinned food. Hospitals produce an extensive range of varied diagnostic, curative and care services. A car also produces a range of outputs such as transport services, heat, noise and atmospheric pollutants.

The source of the problem lies in the (virtual) irreversible nature of the process of nuclear fission. In all 'normal' activities, if it is decided to cease production, then the revenue and cost streams come to an end and opportunity cost is, in the limit, zero. If it is decided to close a railway line then the opportunity cost of, say, a specific asset such as a railway tunnel, will be zero. But with nuclear fission, when production ceases, the opportunity cost of specific assets such as the power plant is *negative,* and will be so for thousands of years. Furthermore the cost stream continues for thousands of years. This is the economic meaning of what we are observing on a massive scale since Chernobyl. I can conceive of no activity other than nuclear fission that has both characteristics of negative opportunity cost and continuing cost streams when production ceases.

Another issue that is relevant relates to the economic phenomenon of discounting. With respect to the economic viability of assets that are long lived, economic theory (correctly) indicates that the monetary time streams of outputs and inputs should be discounted to the present to facilitate comparison. The *effect* of applying any positive discount rate is that the time streams after 30-40 years, in present value terms, count for virtually zero. *Assuming* that the radioactivity associated

with nuclear fission can be correctly valued in monetary terms, the application of a positive discount rate means that present decision makers are 'justified' in ignoring the long-run costs associated with radioactivity as they have so little effect on present values. With respect to radioactivity the application of discounting leads to a bizarre and, I think, generally unacceptable conclusion that the present generation can blithely impose the costs of radioactivity on numerous future generations. The procedure of discounting *is* an appropriate procedure for all 'normal' activities: the argument here is not that discounting is inappropriate. Its inappropriateness lies in being applied to an economic activity that is (virtually) irreversible.

These considerations lead to the conclusion that neo-classical welfare economics cannot be applied to the problem of evaluating nuclear power plants in comparison with other technologies for generating electricity. This arises from the (virtual) irreversible nature of nuclear fission. More specifically, it means that the OECD studies of cost comparisons are *not* economic in nature: they are 'commercial' or 'financial' in nature as they take no account of long term valuations of radioactivity. In other words they have ignored the phenomenon that is most relevant to *public* policy, where this term encompasses all people (present and future) who are affected by the external diseconomy called radioactivity. Owen has, unfortunately, made this error. He describes these OECD studies as "economic comparisons" (p.6).

It is clear that the views expressed here are normative in nature, but given the nature of welfare economics, this is to be expected. A concise definition of welfare economics by Arrow and Scitovsky makes this clear: "welfare economics is the theory of how and by what criteria economists and policy makers make or ought to make their choices betwen alternative policies. . ."[8]

This is not to deny, of course, the signifcance of positivistic economic analyses of the role of government. Two literatures are relevant in this context. First, there is the economic analysis of bureaucracy, in which budget maximising bureaucrats pursue their own interests at the expense of taxpayers.[9] Second, there is the economic critique of government regulation since Stigler[10] which emphasises that government (politicians and bureaucrats) should not be regarded as benevolent or neutral, but rather that government is 'captured' by self-interested groups or coalitions.

CONCLUSION

The major disappointment with Owen's monograph is that virtually no attention is given to radioactivity. ('Externalities' does not appear in his index, for good reason.) Owen admits that his study is "fairly

narrow" and that he is not considering "a number of closely related issues. . . [associated with] the environmental, social and political controversies surrounding the various stages of the nuclear fuel cycle. . ." (p.5). These various controversies revolve around the phenomenon of radioactivity and the previous comments in this review indicate that there is a quite conventional *economic* conceptual framework in which radioactivity can be discussed. In other words radioactivity is not simply an environmental, social or political issue: it is also an economic issue. It is unfortunate that welfare economics can offer no guidance on this crucial problem, but if economists can live with Arrow's impossibility theorem,[11] we can also live with this pessimistic conclusion. It is better that we know the limitations of our discipline than to pretend, to ourselves and others, that we have something to say on matters which require our silence or an admission of our ignorance.

The implication of this discussion is clear: there can be no such thing as an *economic* study (as this term is generally understood since Pigou) of certain aspects of the nuclear fuel cycle. If government policy makers take notice of studies, purporting to show the *economic* viability of nuclear power, then they are misleading not only themselves, but also the members of the community. Given that such studies are concerned only with 'financial' or 'commercial' viability, if public policy is based on them then the interest of the community is being equated with the interest of producers: this amounts to an assertion that 'what is good for the nuclear power industry is good for the community'. There are many people that take strong objection to such a proposition as it ignores the costs associated with nuclear power that they, their fellow citizens and descendants have to bear.

NOTES AND REFERNCES

1. For a more detailed account see, e.g., P. Pringle and J. Spigelman, *The Nuclear Barons,* Joseph, London, 1982.
2. Some of the material in this chapter has appeared elsewhere. See A.D. Owen, 'The economics of uranium enrichment', *Prometheus,* 1, 1, 1983, pp.5-22.
3. J.O. Reynolds, 'Uranium fuelled electricity — An Australian perspective', *The Mining Review,* September 1986, p.3. Emphasis added.
4. Reynolds was commenting on the same OECD studies referenced by Owen, and a more recent OECD study published since Owen's book appeared.
5. A.C. Pigou, *The Economics of Welfare,* 4th ed., Macmillan, London, 1932, p.11.
6. For a detailed discussion of externalities see E.J. Mishan, *Introduction to Normative Economics,* Oxford University Press, London, 1981.
7. The wording of these two questions is determined, in part, by Coase's critique of the Pigovian (governmental) tax-subsidy scheme to address the allocational inefficiency created by externalities. Coase's solution, voluntary bargaining by the affected parties, is implied in what is now known as the Coase Theorem. See R.H.

Coase, 'The problem of social cost', *Journal of Law and Economics,* III, October 1960, pp.1-44. Coase argued that any assignment of liability, or property rights, for the uncompensated costs, whether imposed on the genertors of the externality or on the recipients, would achieve economic efficiency. The non-neutral allocational effects of such questions, implying as they do opposite property rights and thus opposite answers to the question 'who has to compensate whom?' has been emphasised by Mishan on the grounds that, for the Coase Theorem to be true, a necessary assumption is that the welfare effect is zero. See E.J. Mishan, 'Pareto optimality and the law', *Oxford Economic Papers,* 19, 3, 1967, pp.55-87. For papers concerned specifically with property rights assignments see E.G. Furubotn and E. Pejovich (eds), *The Economics of Property Rights,* Ballinger, Cambridge, Mass., 1974.

8. K.J. Arrow and T. Scitovsky, 'General Introduction' in K.J. Arrow and T. Scitovsky (eds), *Readings in Welfare Economics,* George Allen and Unwin, London, 1969, p.1.
9. This literature was established by Niskanen. See W.A. Niskanen, *Bureaucracy and Representative Government,* Aldine, Chicago, 1971.
10. G.J. Stigler, 'The theory of regulation', *Bell Journal of Economics,* 2, 1, 1971, pp.3-21.
11. K.J. Arrow, *Social Choice and Individual Values,* 2nd ed., Yale University Press, New Haven, 1963.