Energy and Depletable Resources:

Economics and Policy, 1973-98[1]

by

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Proposed Running Head: Energy and Depletable Resources

[1] Comments from William Hogan, Kerry Smith, Robert Solow and several anonymous referees are much appreciated, though they bear no responsibility for the remaining errors.

Abstract

This paper reviews the impact of the literature in depletable resources and energy economics over the period 1973-98, particularly the period of publication of the *Journal of Environmental Economics and Management*, 1974-98. A discussion of prominent policy issues in this arena is provided, along with an indication of what academic economics papers have contributed to that debate. This is followed by a citation analysis of contributions in the fields of energy and exhaustible resource economics. For each of these two fields, a list of the top papers in each five year period from 1974 to 1998 is presented, along with a list of the top journals in each decade, based on average citations per article. The top ten cited articles in the fields in the *Journal of Environmental Economics and Management* are also presented.

I INTRODUCTION

In the area of depletable resources, much has happened in the quarter century since the *Journal of Environmental Economics and Management* (JEEM) began publication. Though the first issue of the Journal was May 1974, the idea of the Journal and the typescript for most of those first papers undoubtedly date from the period when energy was cheap[2] and OPEC had yet to flex its muscle. The Fall of 1973 brought the OPEC oil embargo, the resulting energy price shock, and the rest is history. For much of the following decade, energy dominated the policy and research agenda in the area of depletable resources. With the collapse in the oil price in 1986, energy issues faded from the agenda for a few years, only to re-emerge in the guise of climate policy in the late 1980's and 1990's.

Non-energy issues in depletable resources were also prominent in the early days of JEEM. In the 1960's Barnett and Morse [7] published their classic analysis of the extent to which resources were becoming more scarce. The 1970's saw renewed interest in these scarcity issues, prompted by oil price rises as well as price increases for many other exhaustible resources. In fact, this could be viewed as an integrating theme of the decade: were we now beginning to feel the bite of resource exhaustion

[2] Although the oil price rise did not occur until the Fall of 1973, energy was beginning to be a serious policy concern before that date. In December 1971, the Ford Foundation commissioned a very substantial study of US energy policy, the *Energy Policy Project* (Ford Foundation [32]). (This was followed up by another study in the late 1970's, Landsberg et al [64].) In late 1972, potential shortages in natural gas supply (due to gas price controls) were expected by some industrial users of gas in the US, particularly electricity generators in Texas and Oklahoma. In 1972 and 1973, Western US coal

(the oil price rise being a prominent example)?[3] In 1976, Kerry Smith assembled a group of scholars to reexamine the results of Barnett and Morse, resulting in the publication of *Scarcity and Growth Reconsidered* (Smith [104]). At approximately the same time, Margaret Slade [99] published her classic articles on the effect on price of the interplay between depletion and innovation in the technology of extraction.

The charge in producing this contribution for this special issue of JEEM was to determine the extent to which the economics literature, particularly JEEM, has contributed to and supported the development of policy in the area of exhaustible resources. This is not an easy task. In particular, what objective evidence is there of what academic research has contributed to making policy?

One problem is that some academic debate is not motivated by policy; thus looking at the literature that contributed to policy will be driven by the policy agenda. Specifically, the vast majority of policy questions in the depletable resources area over the last quarter century have concerned energy. There have been important academic debates concerning non-energy resources (eg, concerning scarcity and growth), but these are generally not motivated by the concerns of policy-makers.

The approach taken here, albeit imperfect, is to first provide a very subjective review of what major policy issues faced the world over the last quarter century in the area of exhaustible resources (a modest task!)[4]. For the most part, this review of

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production was beginning to gear up to serve as an alternative fuel for electricity generation, in part due to stricter emission regulations brought about by the 1970 Clean Air Act Amendments.

[3] People have been worried about running out of energy for a long time. See Jevons [49], who was concerned about running out of coal.

[4] There are other reviews of this literature. For instance, see Peterson and Fisher [82], Fisher and Peterson [31], Devarajan and Fisher [26] and Krautkraemer [60].

policy issues focuses on energy, which has dominated the resource policy agenda over the last quarter century. Regrettably, this review has a North American bias, reflecting the author's experience.

Taking off from this beginning, the remainder of the paper will rely on the published literature to both frame what was of interest (interest will be defined by articles published) and what sources were used in that academic research (i.e., citations to published articles).

II. THE POLICY ISSUES, 1973-1998

Looking back over the last quarter of a century, there appear to be four basic issues that have dominated the energy policy debate, broadly defined, at least in the US: what will happen to energy prices?; what are the consequences of energy price changes in the market?; to what extent is intervention in the market desirable?; and what should be the nature of government intervention in the energy market, when it is necessary? The non-energy depletable resources market was less in the public eye. One question, though more of an academic policy issue, was the extent to which we are "running out" of resources (see Kneese [56]). This same issue is implicit in the question of what will happen to energy prices. In any event, each of these policy questions is a fairly broad subject with a variety of subissues which we can individually examine.

A. Whither Energy Prices?

The 1973 oil price rise[5] certainly caught the attention of consumers around the world, although in many ways it was the physical shortages brought on by the Arab oil embargo (associated with the Yom Kippur war in Israel) and price controls in the US that most concerned the general public.[6] For the remainder of the decade of the 1970's the price of oil and other forms of energy was one of the primary energy policy concerns. Will the Organization of Petroleum Exporting Countries (OPEC) be able to keep prices high? How high can OPEC push prices? How does OPEC work? Will it fall apart? What effect will depletion of energy supplies have on price? More specifically, how will continuing depletion of fossil fuels affect the profile of prices over time? Can we rely on the Hotelling model to forecast prices? To what extent will elevated energy prices induce increased supply of energy and how quickly can this be expected to happen? And what effect will the increased supply have on price? To what extent will elevated prices reduce energy consumption and what effect will this have on price?

B. The Consequences of Energy Price Increases

Of course, when the price of any major commodity rises by a factor of four, as happened with oil in late 1973, the immediate reaction in policy/government circles is that the price rise is harmful. While that is probably the case, the question remains as to how harmful? With inflation accelerating at approximately the same time as the

[5] In October 1973 the U.S. price of imported crude oil went from approximately three dollars barrel to over twelve dollars a barrel (USDOE [113]).

energy price rises in the early 1970's, to what extent should energy price rises be considered to spur inflation? If there is a causal connection, then inflation may subside when oil prices stabilize. Other than inflation, are there other macroeconomic impacts of oil price increases?

Similarly coincident with the oil price rise was the productivity slowdown of the 1970's (Jorgenson [51]). Productivity growth had been at high levels in many countries in the post-World War II era. For many industrialized countries, productivity growth ground to a halt (or significantly slowed) in the 1970's and 1980's. To what extent should the price of energy be held responsible for this?[7] Once again, if energy price rises are a culprit, then stabilizing prices should help.

Another totally separate issue, is the effect of energy price increases (and decreases) on countries that are significant energy exporters. The so-called "Dutch Disease" was identified as a problem with countries which had significant resource exports (Corden and Neary [22]). The idea is that heavy resource exports cause the domestic currency to appreciate; imported goods become less expensive than domestically produced goods, reducing the return on capital in the domestic industrial sector; this tends to cause domestic capital to move to the resource sector, causing the industrial sector to wither. This seems to have operated in reverse in the recent collapse of the Russian ruble. Russia was heavily reliant on oil and gas exports; when

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[6] The Ford Foundation [32] report on energy policy published in 1974: "The energy crisis seems to have vanished as suddenly as it appeared. The gasoline lines are have gone and auto companies are again advertising big luxurious cars."

[7] The consensus now is reflected in Jorgenson and Wilcoxen [52], who estimate that the effect of environmental regulations on productivity was quite modest.

oil prices plummeted in 1998, the ruble collapsed as well. There were of course many other problems in the Russia of 1998, in addition to declining oil prices.

C. Where Should the Government Intervene?

In the years following the 1973 oil price rise, energy policy in the US could be characterized as generally suspicious of the market.[8] The prices of crude oil and products were controlled from the beginning of the oil price rise. Natural gas prices had been controlled for years. Electricity prices were also controlled, though for reasons that were different and more justified (electric utilities were regulated monopolies). Despite these price controls, energy prices did rise, though somewhat more slowly than would have been the case without the controls. A major issue was the extent to which the market could be relied upon to solve the "energy crisis." Would elevated energy prices induce sufficient conservation? Would elevated energy prices induce expanded energy supply? Would elevated energy prices induce sufficient innovation to reduce the energy intensity of production and consumption? The general consensus in early years was that it was not enough to rely on the market, in part (but certainly not entirely) for the very real reason that price controls were preventing proper signals from reaching the marketplace.

Supply augmentation was a major strategy pursued by the US government in addressing the "energy crisis." This involved programs to expand the use of energy resources on Federal lands, to increase R&D into supply technologies, and probably most visible (and expensive) of all, to promote the development of a synthetic fuels

industry by funding demonstration synfuels facilities.[9] This strategy was strongly criticized by Amory Lovins [67] who argued that the energy market would respond to increased prices, greatly decreasing the quantity of energy demanded.

There was also distrust of the market on the demand side of the equation, although in some cases with good reason. Would consumers demand fuel efficient cars and would automakers provide them? Would consumers demand fuel efficient houses and would building contractors supply them? A major tool used to "correct" the market's imperfections was the fuel efficiency standard, applied to buildings, appliances, and automobiles.

With hindsight, it is still an unresolved question how much of the reduction in the quantity of energy consumed was due to price induced conservation as opposed to fuel efficiency standards. Today, in the context of the climate change debate, the question remains of how easily/cheaply energy consumption can be reduced in order to reduce emissions of greenhouse gases. There are two major camps on this issue. One school of thought is that there are numerous opportunities to reduce consumption; it is just that these opportunities have not yet been adopted. The other view is that price is the signal to which consumers respond and if existing technologies have not been adopted it is because consumers have concluded that these technologies are not useful, given relative prices.[10]

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[8] In the Ford Foundation [32] report on energy policy, it is striking that several members of the advisory board for that study criticized the study's reliance on federal planning as opposed to the market mechanism in implementing energy goals.

[9] See Weitzman et al [114] for a discussion of synfuels programs. Schmalensee [95] addresses the general issues of government subsidies to new energy supply technologies.

[10] This is a very long-standing debate, most recently referred to as the "top-down" vs. "bottom-up" approach to analyzing energy consumption (see Hourcade et al [45] and Weyant [115]).

The security dimensions of energy supply have always been viewed as appropriate concerns of the government: most analysts do not view the market as providing sufficient signals to address the problems of the disruption of energy supply due to crises overseas. One could argue that the Gulf War in the early 1990's was simply a form of energy policy, protecting western oil supplies originating in the Middle East.[11] Certainly the dependence of the US on foreign sources of oil in the 1970's was a major concern, implicit in the name "Project Independence," the massive U.S. Government analysis effort to "solve" the energy crisis of the mid 1970's. Countries other than the US (such as Japan) have tried to diversify their sources of energy to reduce the risk of disruption (see Wolak and Kolstad [117]).

Security was also viewed as threatened by sudden fluctuations in the price of oil: thus the establishment of the Strategic Petroleum Reserve (SPR). The SPR is a large store of oil in abandoned salt domes. The idea is that if the price of oil were to rise rapidly due to a disruption in supply, then the SPR could be called upon to provide supplies, thus reducing the price shock. Ever since the SPR was established, there has been controversy over exactly how or when the reserve would be used.[12] The logic was that if a crisis occurred, and prices were driven up, the natural reaction would be to save the stored oil in case things became worse. Only when the crisis began to ease would managers feel comfortable in releasing stored oil; but then the need would have

[11]Another security issue, of a somewhat different nature, pertained to Western European reliance on natural gas provided by the then Soviet Union. This was an issue in the early 1980's and the question was whether it was in the best interest of the US and/or Europe to heavily rely on natural gas from Soviet sources.

[12] Teisberg [111] provided one of the earliest analyses of how to use the SPR. For a recent discussion of the SPR, see Blumstein and Komor [12].

largely passed. So the reserve would remain unused. A more fundamental question regards the necessity and desirability of providing a price buffer; other commodity prices fluctuate without leading to catastrophe.

It is a well-known fact in economics that research and development (R&D) will not be provided at efficient levels by the private market, at least if there are any knowledge spillovers that cannot be appropriated by the innovator, which is usually the case for basic research. Thus an appropriate role for the government is in financing R&D. The conclusion of this debate during the 1970's was that energy research that is risky with a payoff far in the future (more basic than applied research) is appropriate for the government to fund while research with near-term payoff, particularly in terms of commercial payoff, is appropriate for the private sector. But this doesn't mean that all long-shots should be financed by the government. How to decide where to put public R&D monies?[13] And after the fact, how efficient is government R&D, absent the profit motive found in industry? Related to this, if commercialization of a technology (for example, photovoltaics) is a goal, is there any action the government can take to promote this commercialization? Although many felt that an assured governmental market would be all that is necessary to spur private development, the question remains largely unanswered.

[13] This issue of public R&D funding of energy was addressed by Roberts and Weitzman [91]. It has resurfaced in the current greenhouse debate in the context of the value of information about climate uncertainties (see Manne and Richels [68], Peck and Teisberg [79] and Kolstad [59]).

D. The Nature of Government Intervention

It is clear that the government has some role to play in energy markets. At the simplest level, many governments, including the US government, own significant energy resources. How should these resources be developed? What institutions should be used to move them into the private sector?

Electric utilities have traditionally been viewed as natural monopolies and as such have been regulated. With the price rises of the 1970's, the question naturally arose as to whether there were distortions introduced by the way in which utilities were regulated which might exacerbate the introduction of new technologies or the pursuit of energy conservation. One view was that utilities were somewhat insulated from risk and market pressures and thus were pursuing excessively costly technologies such as nuclear power, at the expense of cleaner but less exotic forms of energy supply or energy conservation. One institutional change which had profound effects on the industry was the Public Utilities Regulatory Policies Act of 1978 (PURPA), which among other things required utilities to purchase power from third parties at the "avoided cost" associated with buying that power – i.e., the savings from not having to generate power from a conventional source.

Environmental protection is another obvious arena for government involvement. Clearly the market does not supply an efficient amount of environmental protection. The environment has been a constant companion to energy policy deliberations over this entire quarter-century. In the late 1960's the question of black lung disease affecting underground coal miners was the subject of legislative

attention. In the 1970's, the damage brought on by unregulated strip mining of coal was addressed with legislation. Also in the coal vein, much of the coal in the Western U.S. is owned by or controlled by the federal government. In the mid-1970's, leasing of that coal became bogged down with concerns over the environmental effects of leasing and mining. Air pollution consequences of significant energy development in the pristine and fragile intermountain west was a significant issue. All of the nation's rich oil shale reserves were in western Colorado, not far from many national parks and other pristine areas.

In the late 1980's the issue of climate change resurfaced (it was also an issue in the 1970's). Here the issue is how and to what extent the government should intervene to reduce the emissions of greenhouse gases, largely carbon dioxide from fossil fuel combustion. Many of the same issues that have dominated the last twenty five years of energy policy have been rejuvenated in the climate change debate. For instance, the question of how consumers of energy respond to price signals is just as important now as it was in the 1970's. In the 1970's a central question was how fast new technologies would emerge to reduce energy use. The variant for the 1990's is how fast carbon-saving technologies will emerge in response to a regulation such as a carbon tax.

III. THE CONTRIBUTION OF ECONOMICS TO POLICY, 1973-1998

In the previous section, we attempted to review some of the major policy issues facing policy makers in the last quarter century. We now turn to a highly subjective

appraisal of what economics has contributed to this policy debate. This section is divided along the same policy questions as raised in the last section.

A. Whither Energy Prices?

There were a variety of sub-issues surrounding the question of what might happen to energy prices. What is the nature of demand? What might the OPEC cartel do? What supply might higher prices induce? How do markets price exhaustible resources over time? How much price-induced technical change can we expect? These are all policy issues that anyone involved in energy policy realizes contribute to the question of where prices might go. But these questions are at the same time fundamental questions about how markets work.

Interestingly, a good deal of the economics research on energy demand took place in the 1960's. When oil prices shot up in 1973, there was a very solid research base upon which to build. One of the first econometric demand analyses was of electricity in the UK (Houthakker [46]). Fisher and Kaysen [30] developed a model of electricity demand in the US, using observations on appliance stocks. Balestra and Nerlove [6] developed one of the first dynamic models of demand, a model of natural gas, explicitly recognizing the tie between demand and the stock of energy-using capital. It was on this base that a great deal of additional work took place in the 1970's and 1980's on the quantitative relationship between price and quantity of energy consumed.[14] Although there was a large literature in this area, the papers of Griffin and Gregory [35] and Berndt and Wood [10,11] were some of the more

influential contributions to this literature.[15] What was needed was a consensus on the short-run and long-run price elasticity of demand for different forms of energy. The consensus of that literature is summarized nicely in Bohi [13]. The fact that measured long-run price elasticities tended to be close to unity, suggested that demand would eventually curtail the ability of OPEC to raise prices. In recent years, the liturature has focused more on gasoline demand, the one form of energy which is most resistent to conservation.[16] It seems clear that energy demand work directly influenced policy.

Another policy question concerned whether OPEC would last. Understanding the behavior of cartels, particularly OPEC, was a major research area in the 1970's and 1980's.[17] This involved studying both the operation of cartels as well as the operation of the specific cartel called OPEC. Pindyck [83] actually computed the profit maximizing cartel prices for several cartels. A special issue of the *European Economic Review* in 1976 focused on different models of cartel behavior. Hnyilicza and Pindyck [43], for instance, constructed a model of a two-part cartel, consisting of spender countries and saver countries, reflecting the composition of OPEC (high population, small reserves vs. low population, large reserves). This work helped to understand how the OPEC cartel worked. Undoubtedly, this was of use to policy-makers. However, unlike the case of measuring energy demand, it is difficult to identify instances where these contributions directly aided policy.

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[14] For a review of the energy demand literature, see Slade et al [100].
[15] Slade et al [100] provides one of the more recent reviews of this literature. Berndt and Field [9] includes a number of papers covering the breadth of approaches to measuring the demand for energy.
[16] A review of the literature on gasoline demand is provided by Dahl and Sterner [24]. See Schmalensee and Stoker [96] for recent estimates on the demand for gasoline.
[17] The literature on cartel and OPEC behavior is voluminous. See Griffin and Teece [36] for a review. Griffin [34] provides an innovative empirical test of different models of OPEC behavior.

Much has been made of Hotelling's rule for the pricing of an exhaustible resource, both in a competitive environment as well as a monopolistic environment. Sweeney [110] and Stiglitz [108] both clarified the Hotelling rule in the presence of monopoly and Gilbert and Richard [33] and Salant [93] extending this to the case of a dominant producer with a competitive fringe and several dominant producers, analagous to the case of OPEC. Pindyck [86] and Kolstad [58] extended the model to several imperfectly substitutable exhaustible resources. These models focused on how Hotelling's rule should be adapted to different market structures. However, the question remains as to how well the rule governs price movements for resources. A number of papers attempted to empirically validate Hotelling's model, without a great deal of success, one way or the other. The most well known of these efforts is Miller and Upton [70], who find support in oil price data for the Hotelling principle. Interestingly, their findings are weakened by subsequent work by the same authors (Miller and Upton [71]). Other analyses of the applicability of Hotelling incluude Pindyck [85] and Slade and Thille [101].[18] Heal and Barrow take a different tack, arguing that one should observe a relationship between the interest rate and returns in depletable resource industries. Undertaking empirical work of this nature, they find ambiguous support for the Hotelling model of price formation. One reason it is difficult to empirically validate the Hotelling Principle is that Hotelling involves expectations: rents should rise at the rate of interest *in expectation*. We do not observe expectations. The real world involves many unforeseen events which cause actual prices to move in a seemingly randomly way. It is probably the case that the

[18] See Withagen [116] for a review of this literature.

literature involving the Hotelling rule for pricing exhaustible resources has not had a significant effect on policy.

Another question that was of importance to policy is the extent to which prices would induce technical change. This remains an issue today in the context of greenhouse warming: if carbon prices are increased, how much control-cost-reducing R&D can we expect to see? Unfortunately, the economics literature seems to have been unable to answer this question.[19]

B. The Consequences of Energy Price Increases

Three policy questions identified earlier were the effects of energy price increases on inflation, the effect of energy price increases on the productivity slowdown and the effect of energy price increases on major energy exporters ("Dutch Disease").

Hogan and Manne [44], in a widely circulated paper, argued that energy was too small a part of modern economies to drive inflation. On the empirical side, there are a number of widely cited econometric papers that look for statistical evidence of a macroeconomic effect of the 1973 energy price rise (Darby [25]; Burbidge and Harrison [16]; Perron [80]. Darby [25] investigates whether oil prices drove inflation in the 1970's. Unfortunately, he is unable to conclude whether there was an effect. Perron [80] examines quarterly US GDP data, testing for a unit root. He concludes that only two events have a permanent effect on GDP: the crash of 1929 and the oil price rise of

1973. While this may be of statistical or even macroeconomic interest, it is not a very policy-relevant result. These papers illustrates a common problem: empirical economics is unable to shed light on the empirical issue until a considerable time series accumulates; by then, the issue is less germane. There are exceptions, particularly when cross-sectional data can be used. Grossman and Krueger's [37] cross-sectional analysis of the environmental Kuznets curve is a good example of a timely empirical paper influencing policy (the debate over the North American Free Trade Agreement).

The question of the extent to which oil price rises influenced the productivity slowdown has been addressed primarily for specific energy sectors. For instance, a significant puzzle was why coal mining productivity dropped so much (worldwide) after the oil price shock.[20] In the mid-1970's coal price rose dramatically and productivity dropped. Was this due to the price change or to environmental and safety regulations that were imposed at approximately the same time? Or is this what one would expect: as demand for a resource expands rapidly, more marginal deposits are mined and the workforce expands attracting more inexperienced workers? Although there were several attempts to nail down the exact reason for this decline, no definitive answer emerged from the economics literature.

Although the economics literature first identified the existence of the Dutch Disease (see Corden [21]), the contribution of the literature to helping policy makers

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[19] Kamian and Swartz [55] presented one of the earlier models of price induced technical change. More recently, Jaffe and Stavins [48] empirically examined the evolution of efficiency in window air conditioners in response to the price of electricity.

solve the problem is less obvious. In recent years, the Russian economy suffered from the Dutch Disease with the Ruble exchange rate driven up when oil prices were high and then collapsing with the collapse in oil prices that was coincident with the Asian financial crisis in 1997-8. Much of the economics literature seeks to identify the presence of the disease (eg, Benjamin et al [8]) rather than offering policy solutions.

C. Where Should the Government Intervene?

Particularly in the 1970's but in the 1990's as well, the issue arose of whether or not the government should intervene in the operation of particular markets; e.g., fuel price controls, electric utility deregulation, energy R&D, and energy efficiency. To what extent has economics shed light on this quandry?

Soon after the 1973 OPEC price action, the US government embarked on a very large effort to analyze the operation of the energy market, predict how the market might evolve, and determine appropriate interventions that might reduce the negative impacts of the changed energy market on the US economy. This was "Project Independence" (Hausman [41]). This work embodied the state of the art of economic analysis of various dimensions of the energy market. Demand models were estimated, supply models were elucidated and a number of complex general and partial equilibrium models of the energy market were developed. This suite of analysis tools was instrumental in shaping energy and environmental policy. Although it is difficult to point to a single set of academic papers which made this development possible, it is

[20] See Sider [98], Kruvant et al [61] and Rittenberg and Manuel [90] for empirical analyses of the decline in coal mine productivity.

clear that without a solid academic economics base, this level of analytic capability would not have been possible.

Similarly, it is difficult to point to any set of academic papers which can be said to be responsible for the deregulation of energy prices in the late 1970's and early 1980's. There was clearly a political mood swing, and it encompassed other sectors as well (eg, airlines, telephony, railroads and trucking). Undoubtedly, part of this mood swing was due to the accumulated evidence that consumers and producers respond to price signals and thus that regulation often introduces undesirable secondary consequences. But it is also true that part of this swing in mood had nothing to do with economic evidence and was the result of conservative Republicans gaining power in Washington.

Turning to specific polity questions, electric utility deregulation appeared on the agenda in the early 1980's, receving impetus from the important book by Joskow and Schmalensee [54]. These authors made a good case for degregulation of parts of this sector yet it is only now, in the 1990's that any significant move to deregulate electric power is taking place in the US. However, other countries did make a move to deregulate the power sector. In the late 1980's Britain broke up the Central Electricity Generating Board into private unregulated entities, though retaining regulated transmission and distribution sectors. Other countries, such as New Zealand and Chile followed suit.

Another issue concerned consumer behavior and whether consumers would demand energy efficient products in response to energy price increases. If consumers

adequately take into account price signals, then no further action may be necessary to induce energy efficiency; if not, then supplemental government programs would be necessary. Certainly the policy assumption was that consumers do *not* adequately account for energy price in their decision-making. This accounts for the energy efficiency programs such as building standards, appliance standards and automobile fuel economy standards, to name a few. The economics literature has been a little ambiguous on this point.[21] Some literature suggests that consumers are rational, perhaps with a high discount rate. But in the early 1990's there was a move to tighten the automobile fuel efficiency standards. At that time, policy makers were unable to determine, based on the economics literature, whether or not the fuel efficiency standards of the 1970's had made any difference, over and above what price would be expected to induce.

Research and development has always been an area of significant government investment in the energy sector. In the 1970's R&D often extended to the commercialization stage where government funds would be used for building facilities to demonstrate new energy technologies. This was highly controversial. A number of papers in the economics literature addressed this question of the appropriate role for the government in R&D (eg, Roberts and Weitzman [91]; Schmalensee [95]; Weitzman

[21] Ohta and Griliches [78] investigated consumer preferences regarding automobiles. Atkinson and Halvorsen [4] examined how consumers make choices regarding fuel efficiency and other automotive characteristics. Some of this automobile-related literature is summarized in NRC [73]. In the area of appliance choice, Hausman [42] examined consumer time preferences in trading off up-front costs for fuel efficiency with delayed expenditures for fuel. Dubin and McFadden [29] constructed new econometric techniques to quantify consumer choices regarding appliances.

et al [114]). Since most of these programs were on their way out by the early 1980's, it is difficult to say that this literature affected policy.

D. The Nature of Government Intervention

A somewhat more modest issue, given that government intervention in a market is desirable, is exactly what form should the intervention take? How to regulate or deregulate electric utilities? How to provide environmental protection? How to lease publicly own resources, such as coal and oil? How to use government incentives to appropriately manage climate change? How to effectively buffer price shocks from overseas supply disruptions?

Deregulation of electric power is an issue of the 1990's and beyond, despite the widespread discussion that accompanied Joskow and Schmalensee [54]. There is the question of which parts of a vertically integrated electricity supplier can be subject to unfettered competition and which parts are natural monopolies which should remain regulated. How to effectively regulate those parts which remain regulated -- eg, rate-of-return, price-cap or other? How to deregulate when there are "stranded costs;" ie, costs that have not been recovered with rate-of-return regulation yet whose market value is lower than the remaining costs to be recovered, such as expensive nuclear power plants? How to construct auctions to allow the smooth interaction between multiple consumers and producers interacting with the "grid" as the intermediary. All of these questions are important to effect deregulation. It would appear that the academic economic community is playing a key role in designing and constructing the

appropriate mechanisms to permit structuring of a deregulated industry, both in the US and abroad.[22]

Environmental protection, though not strictly an energy or resources issue, is intimately tied to energy policy. Most air pollution derives from the combustion of fossil fuels; many of the environmental debates of the last quarter century have been intertwined with energy issues. Controlling climate change amounts to reducing energy use or at least changing the mix of energy used. To a large extent, acid deposition control involves controlling sulfur emissions from coal-fired power generating stations. Urban ozone control is in large part a matter of controlling automobile emissions. Great strides have been made in introducing economic incentives into environmental regulation, an issue which is taken up elsewhere in this special issue. No doubt a major reason for the introduction of economic incentives is the large amount of economic research on the efficiency gains from such instruments.[23]

One of the major policy thrusts in the decades following the oil price increase was to expand the use of federal deposits of minerals, particularly oil and gas. One of the questions facing policy-makers was how to structure leasing so that private objectives aligned with public objectives. There was a great deal of research on this issue (eg, Leland [65]; Reese [88]). Although it is difficult to identify evidence, it is likely that some of this work made its way into the design of federal leasing and bidding systems (see Porter [87]).

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[22] There is a voluminous literature on dimensions of deregulation, including auction systems, pricing systems and operations. Newbery [74] discusses some issues in the case of the UK. See Chao and Peck [19] for a discussion of pricing of a decentralized electric power industry.

Climate change policy has been one of the major energy issues of the decade of the 1990's, though it has been percolating in the background for decades. The US policy regarding controlling precursors of climate change is very much in a state of flux. Although the Kyoto Protocol has been signed by a number of countries, including the US, it has been ratified by few. The question of the optimal, from a cost-benefit point of view, intervention to control greenhouse gases has been addressed by a number of authors, most prominently Nordhaus [76]. Although it is too early to be sure, it would appear that the many papers addressing the effects of various interventions to protect climate have had a significant effect on US Government policy. This is certainly reflected in the US Government's analysis of actions to take to meet Kyoto commitments.[24]

One of the major issues of government policy is managing oil price shocks and disruptions of imports. The Strategic Petroleum Reserve (SPR) was one mechanism chosen to provide some security from price or quantity disruptions. The SPR is a vast store of oil, stored using abandoned salt mines in the South. Unfortunately, as has been pointed out by a number of authors,[25] it is unlikely that the SPR would be used without a carefully developed and precommitted strategy for use. In a disruption, there would be a tendancy to hold onto SPR reserves, in case things get worse. Only when the crisis had abated would SPR reserves be used and that would probably be

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[23] The empirical literature on instrument efficiency is vast. Kneese and Bower [57] provided one of the first examinations of the gains from alternative instruments.
[24] See the analysis prepared by the President's Council of Economic Advisors, led by Prof. Jeff Frankel (Council of Economic Advisors [23]).
[25] See Bohi and Toman [14] for an overview of energy security issues and Devarajan and Weiner [28] for a more technical discussion of SPR policies.

too late to have much effect. An additional issue is how to fill the SPR. It has been suggested that it is optimal to fill the SPR when the price is low and to cease filling or fill less rapidly when the price is high. Clearly the economic research has had an effect on policy-maker understanding of the operation of the SPR, if not, the actual operations of the SPR.

IV. THE ECONOMICS LITERATURE, 1974-1998[26]

It is one thing to identify the energy and resource policy issues of the last quarter century. It is quite another thing to quantify the importance of the academic economics literature in solving these policy questions. In the above policy discussion, an attempt was made to identify important economics papers that had addressed the policy issues enumerated. Beyond this, it is quite clear that economics research generally was instrumental in the formulation of overall energy policy and the resolution of energy-related problems. The abandonment of heavy price regulation of oil and gas in the 1970's was ultimately political; but undoubtedly, the mood was influenced by the accumulation of literature on the problems wrought by regulating various sectors of the economy. Coincident with deregulation of oil and gas was deregulation of trucking, airlines and railroads, among other industries. It is difficult to attribute this policy shift to any one paper or group of papers.

Instead of attempting to answer the question of which journal articles influenced the policy process the most, we will answer the much easier question of

[26] The period 1974-98 is chosen for an examination of the literature (rather than 1973-98) because JEEM did not start publication until 1974.

which journal articles in certain topical areas were the most influential in academic research. This is a question which can be addressed with citations (see Laband and Piette, 1994). We will consider a paper that is used in many other papers (ie, is referenced) as more valuable than a paper that has been referenced in fewer papers. This is of course an imperfect measure, suffering from problems such as self-cites by the author (which are not excluded in our analysis).[27]

The two areas of scholarship we will examine are exhaustible resources[28] and energy[29]. We are interested in what papers have been the most "useful" (ie, cited) over the past quarter century and we are also interested in which journals have been most influential in these topic areas.[30] It turns out to be important to ask these questions

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[27] There are many other problems with using citations as a measure of value. If two papers were published in different years, then they have been available for citation over different periods. A citation is not necessarily a measure of value. Papers that others find fault with are often cited (negatively). Survey papers attract many cites but are not necessarily contributions to economics. The quality of the citing paper is often ignored in tallying up cites. The problems with using citations as a measure of value are well documented elsewhere.

[28] From the point of view of the computer search of papers on exhaustible resources, we have defined the appropriate set of papers as ones containing any of the words "exhaustible," "depletable," "nonrenewable," "minerals," "natural resources," or "hotelling and valuation" In the case of natural resources, an attempt was made to exclude valuation and renewables. The reason for excluding valuation is that natural resource damage assessment has come to be the moniker for valuing environmental resources, without concern for whether they are renewable or nonrenewable resources. These identifying words, with plurals, would appear in the title, abstract or list of key words. Prior to 1990, papers with the word "resource" or "resources" were also included; this is a broad category from which inappropriate papers were manually culled, as they were in all other automated searches.

[29] From the point of view of the computer search of papers on energy, we have defined the appropriate set of papers as ones containing the words "energy," "oil," "petroleum," "coal," "gas," "electricity," "greenhouse," "global warming," "climate change," "acid rain," or "acid deposition." These identifying words would appear in the title, abstract or list of key words.

[30] Citations were generated by searching the Social Science Citation Index, using the Web of Science, an internet resource for searching the Citation Index. Citation data is as of October 20, 1998. Because the word energy is so ubiquitous, we limited the search to the following economics journals: *American Economic Review, American Journal of Agricultural Economics, Canadian Journal of Economics, Econometrica, Economic Inquiry, Economic Journal, Economic Record, Economica, Energy Journal, Environmental and Resource Economics, European Economic Review, Journal of Business, Journal of Development Economics, Journal of Environmental Economics and Management, Journal of Economic Behavior and Organization, Journal of Economic Dynamics and Control, Journal of Economic Theory, Journal of Finance, Journal of Industrial Economics, Journal of Law and Economics, Journal of*

at different points in time because journals definitely rise and fall within specific areas of research in economics. In the 1970's, the *Bell/Rand Journal of Economics* and the *Review of Economics and Statistics* were both very significant journals in the area of energy economics; they have considerably less impact in this area in the 1990's.

A. The Most Cited Papers

Table I shows the top three cited papers on energy in each of the five year periods 1974-8, 1979-83, 1984-8, 1989-93, 1994-8, spanning JEEM's history.[31] Note that it the first decade, the most cited energy papers were dominated by two papers by Ernst Berndt and David Wood [10,11]. Both papers were concerned with the relationship between energy and capital in an aggregate production function for the manufacturing sector. The issue was whether energy and capital were substitutes or complements. If substitutes, then capital could take the place of energy over time; if complements, then growth in the capital stock would involve more energy consumption. It wasn't at all clear *ex ante* which should be the case. It seemed plausible that more efficient capital could replace energy. It also seemed plausible that energy use accompanies capital – more capital, more energy. Thus it was an

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Political Economy, Journal of Public Economics, Journal of Regulatory Economics, Journal of Urban Economics, International Economic Review, Land Economics, Natural Resources Journal, Quarterly Journal of Economics, Resource and Energy Economics, Review of Economics and Statistics, Review of Economic Studies, Bell/Rand Journal of Economics, Southern Economic Journal, Scandinavian/Swedish Journal of Economics, and *Southern Economic Journal.* Not all of these journals were indexed during the entire 1974-98 period. For instance, the Energy Journal began being indexed in 1994. Furthermore, there are other journals that publish economics articles that are not included. It is hoped the main outlets are included, however. Journals that are relevant to energy and resources but are not economics journals are excluded (such as *Energy Policy*).

[31] We should note that the search on the energy topic was imperfect. It is likely that papers without just the right keywords or with a title that is a little different, but nevertheless an appropriate paper, have been excluded. For instance, we failed to pick up Devarajan and Fisher [27]. Furthermore, Perron [80] and Burbidge and Harrison [16] are basically econometric papers and highly cited by

empirical question that Berndt and Wood not only introduced to the profession but was used to clarify the nature of energy demand. In the 1980's, attention shifted to industrial organization issues associated with coal contracts and property rights problems associated with oil production. These were important issues as the US moved towards a reliance on markets for the management of energy resources. Then as we turn to the 1990's, we find that the agenda is dominated by concern for climate change. In fact, of the top six papers in the 1989-98 period, four of the six concern the greenhouse effect (and most of them are authored or co-authored by William Nordhaus, a leader in this arena).

Table II presents a similar set of figures for the exhaustible resource area. The 1970's were a time of profound growth in the exhaustible resource literature. A number of very influential articles emerged in that time period, particularly regarding optimal depletion. In the 1980's the profession turns to the question of scarcity, as reflected in Margaret Slade's important paper on the interaction between depletion and technological change in determining resource prices. A long-standing debate concerned the extent to which resources were becoming more scarce. Obviously, mining of resources leaves less physical quantity in the ground. However, most measures of scarcity had shown that resources were becoming more plentiful. Slade [99] attempted to measure the dual changes in scarcity and technical progress in extraction, pointing out that eventually scarcity should overtake technical progress. Several other papers in the 1980's pick up on the theme of measuring resource

econometricians; they happen to test the effect of the oil price shock on macroeconomic data and thus show up in our search.

scarcity. In the 1990's the dominant theme becomes sustainability and the question of how to modify national accounts to reflect natural resources and the environment.

If one compares Table I and Table II, it is striking that energy has received much more attention in the literature than non-energy exhaustible resource issues. This may be because energy is considered to be more closely tied to policy issues. Nearly all papers in Table I are empirical whereas a significant number of papers in Table II are theoretical.

B. The Most Cited Journals

We have seen the papers that had the most impact on energy and exhaustible resources. Which journals tended to have the most impact? An examination of citation rates indicates that there are clear leaders among the journals. The citation rate is the average citations per article in a subject area over a specific period of time.[32] Using citation rates to rank journals, Table III lists the top five journals in exhaustible resources (excluding energy) during each of the three decades of interest to us here. The first thing to notice is that there were more seminal articles in the 1970's. The top five journals have citation rates exceeding 30 cites per article, a rate that has only rarely been achieved since. There is of course some bias built into this measure in that earlier papers have longer to accumulate citations. Nevertheless, a glance at Table III will support the contention that the 1970's were a time of high impact papers. The *Journal of Political Economy* dominated the first two decadal

[32] If there are n papers during a specified period of time in a topic area in a journal and there are m cites to those n papers, occurring anywhere at any time, then the citation rate is m/n.

periods, not with the number of papers (only a paper every other year) but with the impact of these papers. The *Bell* (now *Rand*) *Journal of Economics* was very prominent in the 1970's but become much less influential by the 1980's. JEEM has been prominent in this field, finding itself in the top five list during the 1980's and not far out of the top five in the 1990's.

Table IV presents similar data for the field of energy economics. Certainly the 1970's were a time of highly productive journals but the field has not dropped in activity as much as non-energy exhaustible resources. The citation rate continued at a brisk pace in the 1980's and into the 1990's. Furthermore, the "general interest" journals such as the *JPE* and the *AER* have continued to be prominent in the field up to the present. In the 1990's, the field journals of *Resource and Energy Economics*, JEEM, *Land Economics* and the *Energy Journal* had impact factors ranging from 2.4 to 1.4.

The results in Tables I-IV suggest that the life-cycle of a field of study begins with several very influential papers, followed by a much larger quantity of papers, on average less influential. Though there may still be influential papers after the beginning of research in an area, the sheer numbers of papers tend to dilute the measures of journal impact. Furthermore, field journals, by their very nature, are an outlet for a much larger quantity of papers, many of which are important but not necessarily ground breaking. This is not a criticism but a reality. Thus one would expect citation rates to be lower for field journals.

C. The Impact of JEEM

One question that is of importance in this special issue of JEEM is how well JEEM has done in the energy and exhaustible resources field. The citation impacts tell one story and that is that JEEM has been visible and prominent in the exhaustible resources field but somewhat less visible in energy.[33] Table V lists the articles in the combined fields of exhaustible resources and energy that appeared in JEEM and have had the most citations over the past quarter century. Note that every one of these papers is in exhaustible resources rather than energy. JEEM has had important energy-related papers; the top cited paper (Casler and Hannon [18]) received eleven citations. But because of the significance of the non-energy exhaustible resource papers, this was not enough to make the top ten list.

Historically, the environment has not been central to the energy economics literature, a traditional focus of JEEM. Of the next five top cited energy papers in JEEM, all of them concern pollution – oil spills, the sulfur allowance system in the US or global warming. As has been pointed out in the context of Table I, in the 1990's the energy literature is dominated by the question of global warming. It would thus be very plausible that a 2009 (a decade from now) retrospective of JEEM's presence in the energy area, would find very significant impact during the 1990s'.

V CONCLUSION

This paper has examined the contribution of the economics literature to the policy and academic debate over exhaustible resources and energy over the last

quarter century. This has been an exciting and productive period for economics. Each decade from the 1970's to the 1990's has involved different policy and economics issues. And many issues seem to cycle in importance. In the 1970s', energy demand and OPEC behavior were of foremost interest. In the non-energy exhaustible resource arena, the question of optimal depletion and scarcity dominated the agenda. In the 1990's sustainability is dominant in the resources arena whereas global warming dominates the energy field. In some sense, environmental concerns are now the dominant force in shaping both exhaustible resource and energy economics.

In the energy area, we examined four different general policy questions: where are energy prices going?; what are the consequences of energy price changes?; where should governments intervene?; and what should be the nature of government intervention? Interestingly, the apparent contribution of economics to these four policy issues varies dramatically. The economics literature seems to have made an impact on policy related to the future evolution of energy prices. Clearly the economic base on demand estimation and equililbrium models played an important role in the policy debate. On the other hand, it is difficult to detect much of an impact of economics on understanding the consequences to the economy of energy price changes. In terms of identifying where government should intervene, economics provides and important base of knowledge to address that question even though it is difficult to identify specific instances where academic research has led to policy changes. On the last question, what should be the nature of intervention, the academic economics literature seems to have had the greatest impact. In many cases, economics research

[33] JEEM's average citations per article in the energy area during the 1990's is a very respectable 2.3.

has been used to design regulatory and other interventions in the economy. Perhaps the reason for these differences is that using economics to understand something new (such as the OPEC cartel) is a slow process, involving building a literature as well as data. Policy-making usually is more impatient. On the other hand, designing intervention involves the use of existing economic tools. Furthermore, intervention is always being fine-tuned and sometimes radically changed. Thus the slow pace of some economic research is no hindrence.

It is tempting to say that the economics literature has had little impact on many policy issues. That would be an incorrect interpretation of these results. It is clear that basic understanding of energy and resource markets as well as markets in general has been indispensable in formulating rational energy and resource policy. This suggests that basic research as opposed to policy-oriented economics research, should be supported at a much higher level. Looking for the immediate policy impact of economics research is short sighted.

The citation analysis does not directly address the question of the effect of economics on policy. What the citation analysis does is indicate where the literature was focused during different periods of the last quarter century. Several patterns emerge. First of all, energy is a larger literature than non-energy depletable resources. This was less so in the 1970's but is particularly pronounced in the 1990's. There are many reasons for this, including the decline in prices of nonrenewable resources over the last quarter century as well as the rise in concern for environmental problems related to the combustion of energy (eg, global warming).

The *Journal of Environmental Economics and Management* has been a visible and influential journal over this entire period. Several of the classic, top-cited papers to appear anywhere over the last quarter century appeared in JEEM. However, JEEM's visibility has been very largely in the area of non-energy depletable resources. None of the top ten cited articles in JEEM involve energy. This may change soon. Energy is now more than ever coupled with pollution in the literature. Since pollution is a central theme in JEEM, one would expect more energy-related papers to emerge. In summary, JEEM has been very visible and influential and we should expect this to continue into the next millenium.

Table I: Top three most cited energy papers in each five year period, 1974-98.

NB: Excludes survey papers; the energy field is defined in a footnote to the text as is the set using the Social Science Citation Index.

1974-8
Berndt and Wood [10], "Technology, Prices and the Derived Demand For Energy"
Hudson and Jorgenson [47], "US Energy Policy and Economic Growth, 1975-2000"
Griffin and Gregory [35], "Intercountry Translog Model of Energy Substitution Responses"

1979-83
Berndt and Wood [11], "Engineering and Econometric Interpretation of Energy-Capital Compl
Hausman [42], "Individual Discount Rates and the Purchase and Utilization of Energy-Using
Hamilton, J.D. [39], "Oil and the Macroeconomy Since World War II"

1984-88
Joskow [53], "Contract Duration and Relationship-Specific Investments – Empirical Evidence from Coal Markets"
Balassa [5], "Exports, Policy Choices, and Economic Growth in Developing Countries after the 1973 Oil Shock"
Burbidge and Harrison [16], "Testing for the Effects of Oil-Price Rises Using Vector Autoregre

1989-93
Perron [80], "The Great Crash, the Oil Price Shock, and The Unit-Root Hypothesis,"
Nordhaus [75], "To Slow or Not to Slow – The Economics Of the Greenhouse Effect"
Schelling [94], "Some Economics of Global Warming"

1994-98
Mendelsohn et al [69], 'The Impact of Global Warming on Agriculture – A Ricardian Analysis'
Laffont and Tirole [63], "Access Pricing and Competion"
Nordhaus and Yang [77], "A Regional Dynamic General-Equilibrium Model of Alternative Climate Change Strategies"

Table II: Top three most cited nonrenewable resource papers in each five year period, 1974
NB: Excludes survey papers; the nonrenewable resource field is defined in the text as is the
covered.

1974-8
Solow [105], "Economics of Resources or Resources of Economics"
Ciriacy-Wantrup and Bishop [20], "Common Property as A Concept in Natural Resources Polic
Solow [106], "Intergenerational Equity and Exhaustible Resources"

1979-83
Pindyck [84], "Uncertainty and Exhaustible Resource Markets"
Runge [92], "Common Property Externalities -- Isolation, Assurance, and Resource Depletion i
a Traditional Grazing Context"
Slade [99], "Trends in Natural Resource Commodity Prices – An Analysis of the Time Domain

1984-88
Brennan and Schwartz [15], "Evaluating Natural Resource Investments"
Solow [107], "On the Intergenerational Allocation of Natural Resources"
Reinganum and Stokey [89], "Oligopoly Extraction of a Common Property Natural Resource --
The Importance of the Period of Commitment in Dynamic Games"

1989-93
Hartwick [40], "Natural Resources, National Accounting and Economic Depreciation"
Adelman [1], "Mineral Depletion, with Special Reference to Petroleum"
Morrisette [72], "The Evolution of Policy Responses to Stratospheric Ozone Depletion"

1994-98
Asheim [3], "Net National Product as an Indicator of Sustainability"
Toman [112], "Economics and Sustainability – Balancing Trade-offs and Imperatives"
Lopez [66], "The Environment as a Factor of Production – The Effects of Economic Growth and
Trade Liberalization"

Table III: Five Highest Impact Economics Journals in Exhaustible Resources

NB: Average citations per article is used to rank journals. Excludes journals with only one decade.

Journal	# Cites	# Articles	Avg Cites per Article
1974-79			
Journal of Political Economy	269	4	67
Review of Economics and Statistics	123	2	62
American Economic Review	362	8	45
Bell Journal of Economics	119	3	40
Review of Economic Studies	439	14	32
1980-89			
Journal of Business	116	2	58
Journal of Political Economy	212	7	30
Scandinavian Journal of Economics	97	6	16
Econometrica	102	9	11
Journal of Env. Econ. and Mgmt.	318	36	8
1990-98			
American Economic Review	32	2	16
Review of Economics and Statistics	26	2	13
Journal of Public Economics	75	7	11
Scandinavian Journal of Economics	50	9	6
Journal of Development Economics	20	4	5
Review of Economic Studies	10	2	5

Table IV: Five Highest Impact Economics Journals in Energy

NB: Average citations per article is used to rank journals. Excludes journals with only one decade.

Journal	# Cites	# Articles	Avg Cites per Article
1974-79			
Review of Economics and Statistics	540	9	60
Journal of Political Economy	167	3	56
Bell Journal of Economics	692	17	41
American Economic Review	397	16	25
Southern Economic Journal	147	9	16
1980-89			
Econometrica	467	2	233
Journal of Political Economy	212	6	35
American Economic Review	335	13	26
Journal of Law and Economics	91	5	18
International Economic Review	70	5	14
1990-98			
Economic Journal	304	17	18
Journal of Political Economy	45	3	15
American Economic Review	252	19	13
Review of Economic Studies	18	2	9
Journal of Finance	41	5	8

Table V: JEEM's Greatest Hits in Depletable Resources and Energy

NB: Citations are from the Web of Science version of the Social Science Citation Index, as of
Definitions of fields may be found in the footnotes in the text.

RANK	AUTHOR	TITLE	YE
1	Slade	"Trends in Natural-Resource Commodity Prices – An Analysis of the Time Domain"	198
2	Schulze	"Optimal Use of Non-Renewable Resources – Theory of Extraction"	197
3	Smith	"Control Theory Applied to Natural and Environmental Resources – Exposition"	197
4	Hall & Hall	"Concepts and Measures of Natural Resource Scarcity with a Summary of Recent Trends"	198
5	Burness	"Taxation of Non-Replenishable Natural Resources"	197
6.	Stollery	"Mineral Depletion with Cost as the Extraction Limit..."	198
7	Arrow & Chang	"Optimal Pricing, Use and Exploration of Uncertain Natural Resource Stocks"	198
8	Smith	"Measuring Natural Resource Scarcity – Theory and Practice"	197
9	Johnson et al	"Natural Resource Scarcity – Empirical Evidence and Public Policy"	198
10	Peterson	"Model of Mining and Exploring for Exhaustible Resources"	197

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