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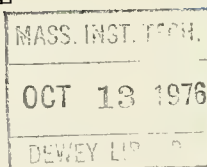
COMMERCIAL IMPOSSIBILITY, THE URANIUM MARKET,  
AND THE WESTINGHOUSE CASE

by

Paul L. Joskow\*

Number 186

September 1976



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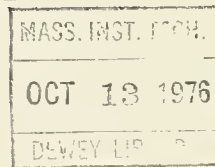
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## INTRODUCTION

On September 8, 1975, Westinghouse Electric Corporation, a major vendor of nuclear reactors and a major contractor for uranium fuel, announced that it would not honor fixed price contracts to deliver nearly 70 million pounds of uranium.<sup>1</sup> Westinghouse claimed that it was not legally bound to honor these contracts by appealing to the rarely used section 2-615 of the Uniform Commercial Code (UCC) which allows excuse from the performance of contractual obligations for reasons of "commercial impracticability". In particular that for "unforeseeable" reasons uranium prices had risen to levels several times those at which Westinghouse had agreed to deliver uranium to utilities and that performance on such contracts, with a potential loss of as much as \$1.5 billion,<sup>2</sup> was "commercially impracticable". Subsequent to this announcement 16 utilities in 13 separate actions sued Westinghouse in Federal Courts for breach of contract.<sup>3</sup> As of August 1976 these cases were still pending.

These events attracted my interest as an economist for a number of reasons. First, that fixed priced long-term contracts might be legally voided because the cost of performance had increased dramatically was something that I had never seen discussed in the economics literature and seemed to be in conflict with general presumptions about the sanctity and enforceability of contracts. The implications of such a doctrine seemed worth exploring in terms of its possible effects on resource allocation. Second, the events surrounding Westinghouse's actions, my other ongoing work on the nuclear energy industry,<sup>4</sup> and recent theoretical research on pricing in natural resource markets suggested to me that price formation in the uranium market was not well

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understood. In addition since the uranium market was a relatively new market with private buying and selling occurring only since 1968, it appeared to be an ideal market to study for better understanding the evolution of market institutions that lead to price adjustments in competitive markets.<sup>5</sup> Finally, the outcome of the Westinghouse case and the possibility of many more cases like it could have important implications for the effects of contract law on the process of voluntary exchange.

This paper attempts to deal with all three of these interests. Section II of the paper discusses the legal doctrine of "impossibility" and analyzes the effects of alternative interpretations on resource allocation. Section III is an economic history of the post-war uranium industry in the United States aimed at understanding the evolution of feedback mechanisms or lack of such evolution which led to more or less efficient market responses to changes in supply and demand configurations. Sections II and III are for all intents and purposes independent of one another and can be read as if they were separate papers. Section IV puts the material in Section II and III together with regard to the specific claims made by Westinghouse with an effort to both evaluate Westinghouse's contentions based on the law and economics and to discuss possible implications of the ultimate decisions of the courts.



## II. COMMERCIAL IMPOSSIBILITY AND RESOURCE ALLOCATION

An economy based on voluntary exchange can function without a system of contract law. However, especially when we are dealing with exchanges which involve delivery of the promised service or commodity over time and/or payment for the service or commodity over time or where the promised service or commodity is complicated, contract law can help to facilitate voluntary exchange. Posner indicates that the law of contracts can facilitate voluntary exchange in a number of important ways.

1. By protecting parties who perform in good faith from those who do not, the law of contracts reduces the uncertainty of exchange transactions and the costs associated with this uncertainty.<sup>6</sup>

2. Contract law will reduce the costs of transactions directly by setting up a set of normal terms applicable to transactions of a particular type and therefore relieving the parties of the task and cost of negotiating and specifying these terms in every transaction.<sup>7</sup> "Good" contract law will not try to override the inherent economics of exchange transactions by requiring, for example, that it is the duty of the party with the higher costs of inspecting goods to do so, because this will only increase transactions' costs by leading to the specification of a clause shifting the burden back to the other party.<sup>8</sup>

3. Contract law will serve as an aid to parties engaged in voluntary exchange by providing them "...with information concerning the many contingencies that may defeat an exchange, and hence to assist them in planning their exchange sensibly,"<sup>9</sup>

To this list I will also add the following function of contract law,

4. To help to make voluntary exchanges more equitable by protecting parties from signing objectively unfavorable contracts because of a gross inequality in bargaining position or ignorance.<sup>10</sup>

Despite the layman's view of the "sanctity" of contracts there are a variety of situations in which the terms of a contract may not be enforceable.<sup>11</sup> Of concern to us here are the particular situations in which performance on a contract may be excused for reasons of "impossibility" or "frustration". Before discussing the allocative significance of these legal doctrines, let us examine their meaning in the context of the evolution of these doctrines over time.

Prior to the middle of the 19th century, English common law required absolute performance on a contract. Under the "rule of absolute liability" a party to a contract who did not perform his obligations was liable for damages even if such performance had been rendered impossible by events which had occurred subsequent to negotiation and had not been stipulated in the contract itself.<sup>12</sup> The rule requiring absolute performance was first relaxed in 1863 in the case of Taylor vs. Caldwell.<sup>13</sup> In this case both parties to a contract for the rental of a music hall were excused from performance when the music hall was destroyed by fire prior to the date of performance even though this contingency had not been specifically included in the contract. The court held that the parties must have contemplated that the contract would only be honored if the music hall ("some particular specified thing") continued to exist. As a result the fact that performance would not be required if the music hall burned down was an implied condition of the contract and the contractor could be excused from performance for reasons of "impossibility of performance".

The English courts also developed a related concept whereby excuse might be allowed when the purpose of the contract was "frustrated" by events occurring subsequent to the time the contract was signed. In Krell vs. Henry<sup>14</sup> a party who had rented a room for the purpose of viewing a coronation parade was released from having to pay for the room when the parade was cancelled because the King became ill, even though the ability to satisfy the "purpose" of the renter was not explicitly part of the contract.

Both doctrines have been adopted and expanded by American courts. A number of decisions by American courts have allowed somewhat weaker conditions than strict impossibility as a qualification for excuse. In Mineral Park<sup>15</sup> the defendants contracted to haul sufficient sand and gravel from the plaintiff's land to build a bridge. They agreed to pay 5¢ per cubic yard for the sand and gravel taken from the property. The defendants removed only part of the sand and gravel required for the project from the plaintiff's land and acquired the rest elsewhere. The plaintiff sued the defendant to pay him the contract price for the gravel purchased elsewhere. The defendant claimed excuse because the rest of the sand and gravel on the plaintiff's property was under water and the cost of removing it would have been ten to twelve times the contract price. The court accepted the defendant's contention on the ground that it was "impracticable" for reasons of excessive and unreasonable cost.

Commercial impossibility and frustration are both discussed at some length in the Restatement of Contracts (1932). The authors of the Restatement of Contracts seem to have favored discharge of performance under conditions somewhat weaker than strict impossibility including also

"...impracticability because of external and unreasonable difficulty, expense, injury or loss involved".<sup>16</sup> The Restatement provides a list of situations in which performance should be excused. Among these are rules, regulations and actions by the government which makes performance either illegal or impossible, the destruction of things (like the music hall) which makes performance impossible or impracticable, the illness of individuals necessary for performance, and the non-existence of other conditions, the existence of which is necessary for performance, which were either expressly provided for or implied by the agreement of the parties.<sup>17</sup>

Frustration of purpose is discussed separately in the Restatement. "where the assumed possibility of a desired object or effect to be attained by either party to a contract forms the basis on which both parties enter into it, and this object or effect is or surely will be frustrated, a promisor who is without fault in causing the frustration, and who is harmed thereby, is discharged from the duty of performing his promise unless a contrary intention appears."<sup>18</sup>

Impossibility and frustration of purpose are normally discussed together despite their separate treatment in the Restatement.<sup>19</sup> Corbin<sup>20</sup> indicates that when a promisor is sued for non-performance there are three basic kinds of defenses that he can set up.

1. He may assert that superseding events have made his own performance impossible;

2. He may assert that performance of the agreed equivalent has become impossible;

3. He may assert that the purpose for which he made the contract has been frustrated.



All these defenses assert that superseding events have made something impossible. Corbin indicates that it is this common factor that leads to the cases being discussed together.<sup>21</sup> As indicated above, the common law interpretation of "impossibility" (an absolute which rarely occurs in practice) has become gradually broader over time evolving more into a doctrine of "impracticability". Exactly what is meant by "impossibility"<sup>22</sup> has important implication for contracting procedures and resource allocation and appears to be sufficiently vague to lead to considerable variance in practical application.<sup>23</sup> Corbin<sup>24</sup> does indicate, however, that under common law, discharge may be granted when the costs of performance have become extreme, but that this would be an uncommon and extreme case. When the Uniform Commercial Code was written, the authors appear to have adopted the somewhat weaker doctrine of "commercial impracticability" rather than strict impossibility. According to Hawkland,<sup>25</sup> this relaxation in the doctrine of commercial impossibility was largely an effort to give force majeure relief to small businessmen who were not well represented and did not have the proper exemption clauses written into their contracts. Despite the erosion of the doctrine of strict or objective impossibility toward a doctrine of "commercial impracticability", UCC section 2-615 establishes a fairly strict set of conditions for granting a discharge.

The party seeking to be discharged from his obligations under UCC 2-615 must show all of the following.

1. A failure of an underlying condition of the contract must occur. Part (a) of UCC 2-615 reads:

"(a) Delay in delivery or non-delivery ... is not a breach of his duty

under a contract for sale if performance as agreed has been made impracticable by the occurrence of a contingency the non-occurrence of which was a basic assumption made or by compliance in good faith with any applicable foreign or domestic governmental regulation or order whether or not it later proves to be invalid." (See also official comment 10 regarding government laws, rules and regulations.)

2. The failure must have been unforeseen at the time the contract was signed. Official comment 1 reads:

"This section excuses a seller from timely delivery of goods contracted for, where his performance has become commercially impracticable because of unforeseen supervening circumstances not within the contemplation of the parties at the time of contracting."

3. The risk of failure must not have been assumed either directly or indirectly by the party seeking excuse. Official comment 8 indicates that

"The provisions of this section are made subject to assumption of greater liability by agreement and such agreement is to be formed not only in the expressed terms of the contract but in the circumstances surrounding the contracting, in trade usage and the like. Thus the exemptions of this section do not apply when the contingency in question is sufficiently foreshadowed at the time of contracting to be included among the business risks which are fairly to be regarded as part of the dickered terms, either consciously or as a matter of reasonable, commercial interpretation from the circumstances."

Comment 8 also raises the question of whether requirement 2 above really means "unforeseen" or "unforeseeable". The latter is a much stronger requirement than the former. In Lloyd vs. Murphy<sup>26</sup> the court appears to

adopt a common law doctrine of unforeseeability. Hurst<sup>27</sup> appears to accept this view, questions the wisdom of this requirement and suggests that the requirement is probably not controlling.<sup>28</sup> We might conclude at this point that requirement 2 has been interpreted in prior common law and academic thinking as being unforeseeable rather than merely unforeseen. We will return to this issue below.

4. Performance must be impracticable. While relaxing the doctrine of strict impossibility, the UCC appears to have replaced it with fairly strict requirements for "impracticability". Official comment 4 states that:

"Increased cost alone does not excuse performance unless the rise in cost is due to some unforeseen contingency which alters the essential nature of the performance. Neither is a rise or a collapse in the market in itself a justification, for that is exactly the type of business risk which business contracts made at fixed prices are intended to cover. But a severe shortage of raw materials or of supplies due to a contingency such as war, embargo, local crop failure, unforeseen shutdown of major sources of supply or the like, which either causes a marked increase in cost or altogether prevents the seller from securing supplies necessary to his performance, is within the contemplation of this section."

The comment makes clear that increased cost alone is not sufficient; rather that the increase must be "marked". In Mineral Park, discussed above, a ten- to twelvefold increase was considered sufficient. The Restatement of Contracts indicates that the increase should be "extreme and unreasonable" and mentions a tenfold increase as illustrative of the kind of increase that

might be sufficient.<sup>29</sup> Hurst indicates that the courts have been reluctant to allow excuse merely because the cost of performance has increased and the contract become unprofitable.<sup>30</sup> Courts have not allowed excuse in cases arising directly under UCC 2-615 for cost increases of as much as a doubling.<sup>31</sup> It appears then that moderate increases in cost of up to 100 percent do not satisfy the requirement, while extreme increases of 1000 percent or more do. This leaves a considerable area for controversy. Contracts will be enforced even if it hurts, but at some point between a doubling and a tenfold increase in price the contract may become impracticable.

5. The seller must have made all reasonable attempts to assure himself that the source of supply will not fail. Official comment 5 states

"There is no excuse under this section, however, unless the seller has employed all due measures to assure himself that his source will not fail."

Official comment 5 refers to a 1932 case, Canadian Industrial Alcohol Co. Ltd. vs. Dunbar Molasses Co.<sup>32</sup> In this case a buyer sued a seller for failure to deliver molasses that had been contracted for. The seller claimed that its contract implied that it would only deliver if its exclusive source of supply had sufficient production to meet its needs. It turned out that this source of supply, a refinery, had cut its production and could not meet the needs of the seller.

The court held that the contract was still binding: "There is nothing to show that the defendant would have been unable by a timely contract with the refinery to have assured itself of a supply sufficient to meet its needs. The defendant does not even show that it tried to get a contract



from the refinery during the months that intervened between the acceptance of the plaintiff's order and the time when shipments were begun. It has wholly failed to relieve itself of the imputation of contributory fault. (3 Williston on Contracts Sec. 1959) So far as the record shows it put its faith in the mere chance that the output of the refinery would be the same from year to year, and finding its faith vain, it tells us that its customer must have expected to take a chance as great. We see no reason for importing into this bargain this aleatory element."

So it appears clear that both the official comment and the supporting common law case indicate that the promisor must make all reasonable attempts to avoid the failure of the underlying condition. In two cases handed down under 2-615 the court has held that the seller did not qualify for excuse if the failure to perform would not have occurred if the seller had proceeded reasonably to attempt to perform what he had promised. Deardorff-Jackson Co. vs. National Producer Distributors Inc.<sup>33</sup> and Chemtron vs. McLouth Steel.<sup>34</sup>

6. Finally, it also appears that under the common law the seller's own conduct must not have created the situation leading to the impracticability of performance,<sup>35</sup> although this requirement is not specifically mentioned in UCC 2-615.

Other potentially interesting issues arise from UCC 2-615, especially with regard to the allocation of available supplies among alternative buyers should a discharge be allowed. These issues will not concern us here, but rather let us return to our discussion of the functions of contract law and discuss the current state of the impossibility doctrine in this context.

The doctrine of commercial impossibility and frustration of purpose essentially deals with the allocation of risks associated with performance of the contract between the promisor and the promisee. A doctrine of strict

performance or absolute liability essentially puts all of the risks not otherwise provided for in the contract on the promisor, while a weaker rule of discharge inherent in the impossibility doctrine shifts the burden of some of these risks to the promisee. An economic evaluation of the current status of the law must turn on the relative costs of the parties of insuring against these risks and the associated effects on exchange and the behavior of the economic agents involved.

A strict interpretation of the rule of discharge which puts too much of the risk on the promisor would only lead to an incentive for him to write a more detailed and complicated contract, entailing additional negotiating costs, so as to shift some of the risks to the other party. Similarly, a lenient interpretation of the rule of discharge, which for example discharged obligations if costs rose by, say, 50 percent, would either make such contracts unattractive to some parties negating an important risk diversifying function of fixed price contracts and force the promisee to provide for such contingencies in other more costly ways or require that the promisee more completely specify all contingencies under which he expects performance under the contract. In either case an inappropriate rule of discharge can easily lead to increased transactions' costs associated with the process of voluntary exchange. In addition, it could limit further the set of available contingent claims opportunities and lead to inefficiencies arising from an inability to fully diversify risks.

Another unattractive consequence of a rule of discharge might occur if the rule were extremely vague or randomly applied with differing requirements for discharge. This would not only increase the complexity and costs

of the contracting process but also lead to increased litigation resulting both in additional court costs and delays in performance.

On the other hand, a well designed rule of discharge can aid and reduce the costs of the process of exchange. It would be costly if not impossible to lay out a complete contingent claims contract. There are a number of possible contingencies, the occurrence of which can be contemplated by both parties and the effects of which one or both of the parties would like to provide for. Wars, embargoes, government rules and regulations, destruction of key supply facilities, hyperinflation, etc., can all lead to effects on the supply and demand of the commodity in question which would make performance by one or both parties unattractive. These contingencies could all conceivably be listed in a contract along with the possible occurrences of each and the nature of performance in each instance. It may facilitate the contracting process, however, if it is understood or implied in the contract that when events such as this occur and lead to dramatic increases in the cost of performance or the impossibility of performance that the contract will simply be discharged. If parties wanted to provide otherwise, they could write it into the contract explicitly. The key to such a rule of discharge working well is to provide an appropriate and well understood list of occurrences and an appropriate and well-defined standard for calculating what a dramatic increase in cost is.

Finally, a rule of discharge on grounds of impossibility should rule out excuse in situations in which the impossibility results from the actions of one of the parties to the contract or where the promisor could have relatively easily taken actions to avoid the failure of the underlying condition. To provide otherwise might lead to an increase in opportunistic behavior<sup>36</sup>

or encourage inefficient risk taking behavior on the part of the promisor, which in the long run might result in contracting and exchange responses by the promisee which would increase transaction's costs.

There are a number of questions, therefore, that must be answered with regard to the current status of the doctrine of commercial impossibility. To focus the discussion let's consider a particular simple example. Assume that the supplier of some commodity signs a long-term contract to deliver a specified amount of some commodity at a fixed price over a number of years. After the contract is signed, the market price of the commodity in question rises substantially and the supplier seeks to be discharged from his obligation by appealing to UCC 2-615. Following the previous discussion he would have to show the following:

1. A failure of an underlying condition of the contract must occur, the non-occurrence of which was a basic assumption of the contract.

This requirement essentially sets the stage for a discharge. It indicates that certain occurrences may in general appropriately be part of the dickered terms of the contract and an associated insurance premium included in the price with the risk being borne by the seller. In addition, it indicates that certain occurrences may not be part of the dickered terms, the risks not accounted for in the contract price and the associated risks borne by the buyer. The definition of the appropriate occurrences to fall under this requirement depends primarily on the associated requirements of "foreseeability" and "assumption of risk" which help to define the appropriate boundary. As discussed below such a delineation appears to make good sense.



It appears that the courts and the UCC have isolated an open set of occurrences which are perceived to often fall outside the scope of the dickered terms of the contract. These include fires, incapacity of key personnel, changes in government rules and regulation, wars, embargoes, and acts of God which also lead to large increases in the costs of performance. The presumption is that these are uncertain events with low probabilities and with consequences that are difficult to predict and insure against and for which the risks would ordinarily be borne by the seller in bilateral exchange transactions. But whether or not a particular underlying condition of the contract has failed and led to the increased cost of performance rests on the simultaneous consideration of the "foreseeability" test and the "assumption of risk" test. In laying out this particular set of occurrences the UCC is alerting contracting parties to the kinds of occurrences which will often satisfy the foreseeability and assumption of risk test. If in a particular circumstance they wish to provide otherwise, then the provision should be written into the contract explicitly, otherwise they don't have to bother with it and it will generally be assumed that the buyer bears the risk.

This type of provision makes good sense. It helps the contracting process by laying out the kinds of situations in which the courts have generally felt that the buyers have borne or should bear the risk. It therefore helps to save on transactions costs for ordinary exchanges that satisfy "normal" criteria. In extraordinary situations the parties are alerted to the fact that they have to work a little harder in drawing up the contract if they wish the risks to be divided differently.

2. Foreseeability. As discussed above, UCC 2-615 states that the failure of the underlying condition must have been unforeseen by the parties at the time the contract was signed. The courts and commentators seem to have taken a somewhat stronger interpretation, not only must the occurrence have been unforeseen, but also unforeseeable by the parties.

The foreseeability doctrine appears to raise a number of difficulties. To some extent every occurrence is foreseeable. There is always some probability that a fire will destroy the anticipated source of supply, that a key person will die, that various acts of God -- like floods -- will occur, that there will be an embargo or war, etc. In an objective sense, virtually nothing is truly unforeseeable to the extent that theoretically every possible state of the world could be enumerated and some probability assigned to its occurrence.

The foreseeability requirement may only make sense if we introduce the concept of "bounded rationality".<sup>36</sup> Following Simon<sup>37</sup> and Williamson,<sup>38</sup> the concept of bounded rationality recognizes that human beings cannot evaluate all possible states of the world or all available information that might affect a particular situation. While conceptually all possible states of the world could be enumerated with their associated probabilities and "rational" decisions based on the full set of contingencies, in reality the states of the world that can reasonably be considered in making decisions are fairly limited. One way of thinking about the foreseeability doctrine is as delineating the boundary between those contingencies that are reasonably part of the decisionmaking process and those that are not. This recognizes that most contracts are not complete contingent claims contracts including only some subset of all possible occurrences as a reasonable basis

for decisionmaking and appropriately included either explicitly or implicitly in the terms of the contract.

The foreseeability doctrine is therefore more of a "contemplation" doctrine. What occurrences were or should have been included in the negotiations underlying the contract and what contingencies were not? In recognizing such cognitive realities, the courts effectively enforce the contract only over that set of contingencies that was or should have been part of the decisionmaking process. Such a requirement makes good sense because it recognizes the realities of voluntary exchange. To require performance under contingencies that could not efficiently be part of the decisionmaking process would encourage the costly and difficult enumeration of a large number of contingencies, raising the costs of private exchange.

Under a "contemplation" test we would ask: Did one of the parties to the contract contemplate or should one of the parties to the contract have contemplated a certain occurrence and make the probability of this occurrence one of the bases on which the terms of the contract (including the price) were negotiated? If the answer is no, then an additional requirement for excuse has been satisfied, the occurrence not being covered by the contract. If the answer is yes, then the reverse is the case, and we would presume that the risk of the occurrence which has now occurred was covered in the contract.

Under the circumstances it would appear that the "foreseen" interpretation of this requirement would be sufficient. We would ask the evidentiary question of whether one of both parties contemplated the occurrence and whether it formed the basis of their negotiating position. However, a "foreseeability" test appears in principle to have certain advantages. It allows

us to ask a normative question of whether one or more of the parties should have contemplated such occurrences and made them a basis of the terms of the contract. This stronger interpretation provides an incentive to both parties, but especially the seller, to carefully evaluate available information about uncertain occurrences involving supply and demand, of which the seller will often have the best information, and make this part of the dickered terms of the contract. The test then is not only did the parties contemplate an occurrence and make it a basis of the contract, but stronger, should they have done so? This stronger test should encourage more efficient use of available information and help to insure that contingencies are properly reflected in contract terms. This has the effect of not penalizing a shrewd buyer (or, alternatively, rewarding an incompetent seller) who recognizes that the possibility of certain occurrences which should increase the price of the contract even if the seller fails to. In the long run this will serve to eliminate those sellers from the market who do not utilize information about alternative states of the world efficiently, as would occur in a competitive market without transactions costs.

Whatever the strengths and weaknesses of the "unforeseeability" doctrine, it must be admitted that it puts a terrible evidentiary burden on the courts. They must evaluate evidence regarding whether the occurrences were contemplated or should have been contemplated. They must define the boundary on bounded rationality. Especially after the fact it may appear that an occurrence should have been contemplated to a greater extent than it might have appeared before the fact. It is not surprising, therefore, that the courts have not given substantial weight to the foreseeability test, rarely if ever granting excuse based primarily on it.



3. Assumption of risk. This requirement indicates that the assumption of risk by one of the parties may be found not only in the contract itself, but also in the events surrounding the process of exchange for the commodity in question. In essence this is an extension of the foreseeability or contemplation test and allows the courts to examine circumstances surrounding the particular bargain in question. It allows the court to determine whether or not the circumstances surrounding the contract imply the assumption of risk of failure of an underlying condition by one of the parties or the other. In particular, it encourages the court and the contracting parties to examine what the "ordinary business risks" are that appear to be implicit in contracts such as this in the marketplace. It bolsters the "contemplation" test by assuming, unless specified differently, that the implied distribution of risks in the particular contract is that which is normally understood in general contractual relationships of this type and what appear to make sense given the type of contract negotiated and the nature of the economic environment in which it takes place. For example, since one of the primary reasons for a fixed price commodity contract from the viewpoint of the seller is to insure against fluctuations in price, it might be ordinarily assumed that the seller implicitly assumes all risks of price fluctuations unless otherwise specified and that the contract will be honored except in the most extraordinary circumstances. For example, contracts for theaters might by custom (and reflecting the relative costs of risk bearing) imply that the risks of fire are borne by the renter rather than by the owner of the music hall in which case a fire would lead to a discharge being allowed.

4. Impracticability. Even if a seller is able to show that there was a failure of an underlying condition of the contract, the contemplation of which had not and should not have been part of the dickered terms of the contract, and that he did not implicitly assume the risk by events or normal procedures in the environment surrounding the contract, he still must prove that the occurrence was "impracticable". While it is generally believed that the notion of "impracticability" is somewhat weaker than the older doctrine of "impossibility", this wording of UCC 2-615 may also reflect the fact that there is rarely an occurrence which makes performance objectively impossible. No matter what the occurrence, an equivalent source of supply can often be found, although at a price substantially higher than that in the contract.

In essence the impracticability doctrine says that contracts will be enforced even if the above conditions are satisfied, unless it really hurts. Other things being equal, the seller bears all of the risk unless performance is extremely burdensome, in which case the buyer bears all of the risk. If we had two similar occurrences, let's say an embargo, the seller would have to perform if the price rise were small, but would not be required to perform if the resulting cost increase were very large. Such asymmetric treatment of differing consequences from similar events only appears to make sense if we expand our notion of possible contingencies to include elements identified by both event and consequence, and assume that given a particular type of occurrence the size of the consequence and the probability of the consequence occurring are negatively correlated. That is to say, given the set of possible embargoes, those with small consequences are much more probable than those with large consequences. Then we could appeal to the notions of bounded

rationality discussed above and argue that the low probability events are outside of the boundary and not legally part of the contract. For the impracticability test to make sense, it appears that this negative correlation must hold. Alternatively, that the foreseeability test and the impracticability test should be considered together. The impracticability test extends the boundary between those events that are implicitly part of the contract and those that are not. It is not so much that a fire has destroyed the music hall, but that a fire has destroyed the music hall and there is no readily available alternative; a more improbable occurrence. It might be presumed that the occurrence of a fire and the fact that the supplier would supply an alternative is ordinarily (or should be) part of the terms of the contract and an insurance premium included in the price, while real disasters are not part of the contract terms and insurance generally provided by the buyer himself.

5. The seller must make all possible attempts to secure supplies required for performance. When a buyer signs a contract with a seller, he himself is not concerned with how the specified products will be obtained. He will ordinarily simply presume that the seller will secure supplies in the way that seems most efficient to him. The seller could, if he wanted to, specify how he intended to secure supplies and gear the contract price to his success in his endeavors. But this would be a very unusual contract. The buyer wants the commodity and all he will ordinarily be concerned with is its price and quality (broadly defined). Economic efficiency will be served so long as the contract law does not give incentives to the seller to engage in inefficient procurement activities. This requirement essentially reflects the buyer's understanding that the risks associated with procurement of the

commodity contracted for are being borne by the seller and that presumably a premium for bearing any risks associated with procurement, except those discussed under other requirements, has been included in the contract price.

As a result the law should not excuse performance if it has become "impracticable" because the seller has not made appropriate attempts to secure supplies. This means, for example, that if a seller has contracted to deliver potatoes three months from now, waits until the last day to obtain supplies, and then finds that potatoes can only be found at a very high price, he will not be excused from performance if he could have contracted for the potatoes at lower costs during the course of the three months or engaged in other activities to efficiently insure against any losses. Any additional risks, which the seller incurs due to his own procurement activities and beyond those implicit in the risk premium built into the contract price, are his to bear and will not lead to a discharge under UCC 2-615. This provision makes good sense. To allow excuse when the speculative activities of suppliers have led to bad outcomes would inefficiently encourage risk-taking behavior, raising contracting cost both directly and indirectly through an increase in transactions costs that would be associated with buyers trying to counteract the behavior of risk-taking sellers. Another way of thinking about this provision is to say that it discourages certain kinds of "opportunistic" behavior on the part of suppliers speculating on the hope that in the event of a serious loss, the contract will not be enforced.



6. A final consideration not included in UCC 2-615, but included in common law interpretations and academic commentary and particularly appropriate to the (Westinghouse) case at hand, is the requirement that that supplier does not by his own actions cause the situation on which his claim of "impracticability" is based. This consideration is relevant in markets in which the supplier in question is so large that his own activities have significant effects on the price of the commodity in question.

Let's assume, for example, that a large wheat agent has contracted with Russians to deliver a very large quantity of wheat equal to 25 percent of U.S. production over a period beginning one year from now. The firm should recognize two things. First, at current supply levels a 25 percent increase in demand would result in a rather substantial increase in price. Second, that supply is price sensitive for wheat required more than a year from today. What the actual supply price will be next year depends critically on the behavior of the agent. If for some reason he keeps this latent demand secret until next year when he has the requirements, the supply sector will not have time to properly react to actual demands and prices will very likely be very high, although by chance there might be a very good crop and prices could be much lower than this expected value. Alternatively, the agent could enter the futures market now, gradually bidding up the price and encouraging farmers to plant more wheat by effectively "revealing" this demand to the market through his purchasing activities. A procedure something like this is what we would probably expect from profit maximizing firms. But for reasons of stupidity, risk loving, or in reaction to the possibility that the contract might be voided if wheat prices get too high, the firm might be encouraged to take the first strategy in the hope of making a killing if there is a very

good wheat crop. This kind of behavior does not lead to efficient market operation and should be discouraged by contract law. It is an addition to requirement (5) which reinforces the notion that we will encourage all firms to adopt an efficient procurement policy and will not encourage large firms to use their positions to try to manipulate prices and distort the workings of the market.

All things considered, UCC 2-615 as now interpreted does appear to promote voluntary exchange by reducing transactions costs and providing guidance and encouragement for efficient use of information about alternative future states of the world in contract negotiations and efficient procurement policies by suppliers. In general, it sets a fairly strict standard that contracts will be performed unless certain low probability events occur. It also insures that a rule of discharge will not reward suppliers who for one reason or another do not behave efficiently. This section of the UCC does, however, provide an opportunity to create severe market distortions if the various requirements are interpreted too loosely or inconsistently. This is of special concern if we continue to live in a world of rapid inflation, increased uncertainty in commodity prices, protection of "key" corporations, cartelization of the market for key commodities, etc. The Westinghouse case discussed in the introduction may provide an important indication of where this aspect of contract law is going. Before proceeding with an analysis of this case, we must set the stage by discussing the evolution of the uranium market in the United States.

III. THE EVOLUTION OF THE URANIUM MARKET IN THE UNITED STATES: 1948-1975

It is normally assumed by economists that the prices observed in competitive markets completely reflect all relevant information about demand and supply. It is thought that various market institutions, such as contracts and futures markets, will evolve so that buyers and sellers of a particular commodity can rationally and quickly respond to information reflected in changing supply and demand conditions. When such market institutions are working properly, they serve to efficiently link supply and demand expectations in such a way that observed market prices efficiently reflect these expectations. In such a world, a situation in which "expected demand exceeds expected supply at prevailing prices" could persist for only a very short period of time as rational economic agents engage in market transactions which "rationalize" the situation leading to some combination of price increases, demand reductions and increases in supply. When markets operate in this way they have a number of desirable properties. In particular, markets will clear (there will be no shortages), commodities are supplied in the most efficient (least cost) way given available information and supply opportunities, and prices observed in the market will reflect the expected long-run marginal cost of production (properly defined). In addition, such efficient markets serve to economize on the information that any particular economic agent must obtain to make rational decisions, since prices alone reflect all relevant information.

Despite this conceptualization, it has been observed by a number of economists that the nature of the price adjustment mechanisms implicit in it remain quite obscure.<sup>39</sup> Whether it is the Walrasian auctioneer, or some

other hypothesized price adjustment mechanism, efficient price adjustments somehow take place even though all competitive firms are price takers. Efforts to try to understand this price adjustment mechanism, how it evolves, and how it might differ from one market to the next have not been extensive.<sup>40</sup> Yet without such an efficient price adjustment mechanism, competitive markets would not have the desirable properties mentioned above. In natural resource markets like uranium the requirements of price adjustment mechanisms for resource allocation are even more severe. Solow<sup>41</sup> points out that efficient market behavior requires a simultaneous flow equilibrium, and stock equilibrium and gives an example of the kind of undesirable market performance that might arise if the proper "feedback" mechanisms do not exist.

The uranium market itself is of interest for three reasons. First, uranium consumption is projected to grow at a rate of fifteen percent per year over the next twenty years and to become the major source of energy for generating electricity.<sup>42</sup> Since no comprehensive studies about the uranium market exist, this study appears worthwhile in light of uranium's growing importance and the large number of public policies that affect it directly and indirectly. Second, since the uranium market is a rather new market growing from virtual non-existence at the end of World War II to maturity today, it provides a rare opportunity to study the institutional development of a natural resource market and especially the evolution of those "feedback" mechanisms that make the market behave in particular ways. Finally, this study provides the basis for examining the Westinghouse UCC 2-615 case as a specific example of the use of the "impossibility" doctrine to obtain a discharge from contractual obligations.



### The Demand for Uranium

The demand for uranium in the United States today is a function of five factors:

1. The amount of installed nuclear capacity.
2. The amount that the nuclear generating capacity is utilized.
3. The tails assay at which the uranium enrichment facilities are run (since the light water reactors in the U.S. require enriched uranium).
4. The possibility of reprocessing spent reactor fuel and recycling the recovered uranium and plutonium.
5. Government requirements; primarily for weapons programs.

The amount of installed nuclear capacity is a function of the demand for electricity and the relative economics of nuclear capacity compared to alternative generating techniques such as coal and oil. The demand for electricity is itself a function of the price of electricity, the price of substitutes such as oil and natural gas and various demographic variables and weather characteristics.

Since it has been argued by Westinghouse (see Section IV below) that the rise in oil prices subsequent to the Arab oil embargo was the cause of the rise in uranium prices, it is convenient for the purposes of this discussion to examine the economics of nuclear generation in the United States in the context of rising oil prices.

Any effect that the Arab oil embargo would have had on the price of uranium would have worked through its effects on demand expectations. One could argue that the rapid rise in oil prices would lead to a shift away from the use of oil as a generating fuel, increasing the demand for nuclear power facilities directly plus a tendency to shift from the use of oil by final

consumers toward the use of electricity (for heating, for example), increasing the demand for electricity and the derived demand for nuclear power facilities. In short, if one is to conclude that the change in oil prices increased the demand for nuclear power facilities, one must compare capacity expectations before the oil embargo with capacity expectations after the embargo.

There are at least two reasons to believe a priori that the effect of an increase in oil prices on nuclear capacity expectations would be both small and take a long time to work its way through the system. First, it takes nearly ten years to plan and complete construction of a nuclear generating facility in the United States. The maximum number of nuclear facilities that could have been in operation by 1984 was already determined at the time of the Arab oil embargo. Capacity additions could be less than this amount since construction can be delayed either deliberately or due to technical and regulatory problems at almost any point within the planning-construction cycle. Second, the increase in oil prices will not necessarily lead to a net increase in electricity demand expectations if real electricity prices rise along with real oil (and natural gas) prices. The effects of increased oil prices on electricity demand depends upon the movement in the price of electricity relative to its substitutes and the values of the own-price and cross-price elasticities of demand.

In Table 1 projections of installed nuclear capacity for the United States for 1985 and 1995 from various sources made in various years are presented. It is evident that not only have expectations for installed nuclear capacity for this period not increased, but they have decreased fairly consistently since 1970. Factors such a reduced expectations for the demand

for electricity, increased costs of nuclear generating facilities, construction delays, financing difficulties, etc., have all led to reductions in expected nuclear capacity, counterbalancing any effect that increased oil prices might have had.

In addition, if we examine the expectations for installed nuclear capacity in the rest of the non-communist world for 1980, 1985, and 1990, we find that total government projections made since the Arab oil embargo are slightly lower than those made prior to it.<sup>43</sup> More realistic estimates than those made by official government sources reduces expected installed nuclear capacity for 1985 even further.<sup>44</sup>

Other things held constant, the reduction in expected nuclear capacity for the period at least over the next ten years should have also reduced substantially expected uranium requirements. Although the reduced expectation tended to follow fairly quickly after the rise in oil prices, it would, of course, be absurd (and counterintuitive) to say that the rise in oil prices caused a reduction in nuclear capacity expectations. The reduced expectations for installed nuclear capacity are, of course, due to other factors that are largely associated with nuclear technology itself, have nothing in particular to do with the oil situation, but happened to occur about the time oil prices began to rise.

Considering nuclear power capacity alone, we might think that expected demand for uranium would have fallen along with the reduction in nuclear generating capacity. However, we must also consider the other factors that determine uranium requirements. Other things equal, an increase in the enrichment tails assay from .20 percent to .30 percent increases uranium requirements by about 20 percent. The economics of enrichment indicate that the tails assay should vary directly with the cost of enrichment, primarily the cost of electricity, and indirectly with the price of uranium.

Until 1973 the AEC ran its gaseous diffusion plants at .20 percent tails assay. In December 1972 the AEC announced that it would begin to operate its diffusion plants at an actual tails assay of 0.275 percent while maintaining a transactions tails assay of .20 percent until the end of 1974.<sup>45</sup> Thereafter, it would run the enrichment plants at 0.275 percent tails assay or above for both operating and transactions purposes. The change in transactions tails assay was delayed until July 1, 1976, early in 1975 with an increase in the operating tails assay to .30 percent beginning July 1, 1981.<sup>46</sup>

This plan was revised again in mid-1975 providing for a reduction in the operating tails assay to 0.25 percent and the maintenance of the transactions tails assay at .20 percent until July 1, 1977, and then to rise gradually to .30 percent in 1981.<sup>47</sup> Differences between the uranium requirements arising from this "split-tails" policy are being made up by dipping into ERDA's uranium stockpile. This behavior on the part of the AEC (now ERDA) reflects anticipated enrichment capacity constraints in the early 1980's rather than an economic tradeoff between enrichment costs and the value of uranium. The result is that uranium consumption per MWe will increase by between 10 and 20 percent as a result of the increase in the operating tails assay of the enrichment facilities.

Estimates of uranium requirements made prior to 1974 assumed that limited recycling of uranium and plutonium derived from spent fuel reprocessing would begin by 1977.<sup>48</sup> This date appears to be impossible to meet for several reasons. Today there exists no commercial reprocessing capacity and even under the most optimistic projections only limited reprocessing capacity will be available until the mid-1980's.<sup>49</sup> In addition, the costs of reprocessing



have increased so much that there remain uncertainties about whether or not it will even be economic to reprocess spent light water reactor fuel. Finally, major environmental issues surrounding the reprocessing of plutonium have not as yet been settled. The absence of reprocessing facilities and recycling would in the long run increase uranium requirements by about ten percent.

Finally, while the government was the only demander of uranium through the late 1960's (see below), it has a sufficiently large stockpile that it will not need to acquire additional uranium and in fact through its "split-tails" policy will be an effective supplier of (free) uranium to the electric utility industry over the next few years.

Taking all of these factors into account we can re-examine the demand expectations for uranium itself. The reduction in nuclear generating facilities should have acted to reduce uranium demand expectations. The increase in the tails assay and the unavailability of recycling of uranium and plutonium should have increased demand expectations. In Table 2 are reported projections for uranium oxide requirements made prior to the Arab oil embargo and subsequent to it. Comparing the two 1975 projections by ERDA and the 1975 NAC projection presented in Table 2, we see that all things considered projected uranium requirements through 1985 are well below the ERDA (AEC) projections made prior to the oil embargo and rise in oil prices.<sup>50</sup>

#### Filling Uranium Requirements

When building base load coal plants an electric utility will normally attempt to secure a long-term supply commitment for coal either by signing a long-term contract with a supplier or by developing its own coal reserves. For uranium, the matching of long-term uranium requirements with long-term

uranium supply contracts has not occurred in general until very recently.<sup>51</sup> Tables 3 and 4 present the long-term supply commitments for uranium oxide made by the electric utility industry as a whole and the reported unfilled requirements as of January 1, 1974 and 1975. We can see that the industry (at least, in the aggregate) maintained a substantial "short" position in the uranium market to the extent that long-term uranium requirements determined when a plant entered the construction stage were not in general matched by long-term supply contracts. Examining Table 4 we see two things. First, uranium supply commitments are well below expected uranium requirements beginning in the late 1970's, and second, there was a substantial increase in supply commitments during 1974, met primarily from foreign sources.<sup>52</sup> The aggregate figures are somewhat misleading in that a number of utilities thought that they were making at least medium-term supply contracts when they ordered uranium from a reactor vendor acting as a uranium supply agent (Westinghouse), which itself maintained a very large "short" position (see discussion below in Section IV). The failure of demand requirements to be matched even closely by long-term supply commitments has important implications for the behavior of this market, and this will be discussed further below.

#### The Supply of Uranium Oxide

Raw uranium ore is mined from open pit and underground mines. The primary world suppliers are the United States, Canada, Australia, South Africa, Gabon, and France. Mined ore normally has only a very small proportion of uranium oxide (on the order of .2 percent by weight). Therefore, near the mines a milling or processing plant is usually built which uses chemical processes to separate the uranium oxide from the rest of the ore,

leaving concentrated uranium oxide called yellowcake. It is the price of yellowcake at the mill that is normally quoted. Since many mills are vertically integrated backward into mining, we will not necessarily observe a transactions price for ore of various uranium oxide contents, but rather only a price for yellowcake.

Mine-mill complex life has been estimated to average about ten years,<sup>53</sup> depending on the size of the ore body near which it is located. Current milling capacity in the United States is 18-20,000 tons  $U_3O_8$  per year. Existing mills are expected to yield a peak capacity of 22,000 tons per year in 1977, declining after this to reflect uranium ore depletion (see Table 5). Development of new milling capacity is thought to take between three and eight years, depending upon whether we begin with developed reserves, whether open pit or underground mines are necessary, and whether new reserves must be fully developed.<sup>54</sup>

The costs of building and operating a mine-mill complex are composed of the following factors:

1. The costs of exploration and development of uranium reserves. These costs are a function of the  $U_3O_8$  yield per foot drilled and the costs of drilling.
2. The construction costs of constructing a mine-mill complex and associated interest charges. In 1975 the cost of a 1,000 ton/year mill was estimated at \$18 million.<sup>55</sup>
3. The costs of operating and maintaining the mines.
4. The costs of milling the uranium ore. These costs are a function of the materials costs of necessary materials and the  $U_3O_8$  content of the ore milled.
5. Taxes, costs of land and mineral rights, costs of access roads, trans-

portation and other miscellaneous expenses.

Over the past twenty years there has been a secular reduction in the  $U_3O_8$  content of ore delivered to mills, falling from a high of .32 percent  $U_3O_8$  in 1952 to a low of .17 percent ore content in 1975 (see Table 6). In addition the average depth of exploratory holes has increased from 148 feet in 1958 to 482 feet in 1975 (see Table 7), with an associated decline in discovered reserves per foot drilled.<sup>56</sup> In addition, drilling costs increased from \$1.49 per foot in 1973 to \$2.09 per foot in 1974, and another 40 percent in 1975.<sup>57</sup>

Based on depletion alone, other things held constant, the costs of mining and milling uranium would have increased by nearly 80 percent in real terms since the early 1950's. In addition, wages for miners have increased considerably more rapidly than the average rate of inflation.<sup>58</sup> While detailed assessments of the current long-run incremental costs of constructing and operating mine and mill facilities are not readily available, it appears from an examination of the ore quality statistics that discovery rates and costs of key components of the overall cost of uranium oxide have increased substantially in real term since the 1950's. As I shall discuss below, current ore contents of  $U_3O_8$  probably reflect more intensive exploration of old reserves rather than the content that would be realized for the industry if it were in long-run equilibrium.

As with any exhaustible resource, the expected uranium price trajectory depends critically on the reserves of the resource that are expected to be available at various costs of production. Uranium reserve data are reported and referred to in the United States and abroad in a way unlike any other fuel resource. Instead of merely publishing figures for the locations, depth, concentrations, and nature of the host rock as is common for coal,



oil and natural gas, the AEC began very early on to report reserves based on a "forward cost" concept. Uranium reserves are reported in terms of tons of uranium oxide that could be mined at less than forward costs of \$8, \$15, \$30, etc. Forward costs include essentially the variable costs of mining, hauling and milling uranium. Property acquisition costs, finding costs, costs of money, capital costs, ore replacement costs, profits and taxes are not included in the cost estimates.<sup>59</sup> This forward cost concept, therefore, only includes some of the costs that would make up the true long-run marginal opportunity costs of uranium that would determine the floor on uranium prices for a competitive market in long-run equilibrium.<sup>60</sup> (The other component of price other than long-run marginal production costs would be "user cost" associated with a non-replenishable resource.) As a result, the "forward cost" of a particular reserve deposit being mined reflects primarily the short-run variable costs of producing from a developed facility. We would only expect prices to equal forward costs in a situation in which a competitive industry were in a position of excess capacity where demand requirements were not pushing against the constraints of existing capacity.

Nevertheless, it is apparent from reading the literature on uranium prices and uranium reserves that many people in the industry thought of forward costs of reserves being mined as good approximations to market prices. The AEC and international organizations such as the OECD and IAEA discuss the costs of uranium for power reactors in terms of the forward costs concept and tend to equate expected prices with forward costs.<sup>61</sup> The fact that actual transactions prices were for several years approximately equal to the reported forward cost figures for the low cost reserves that formed the major basis for discussion of future reserves reinforced such tendencies to confuse forward costs with long-run market prices.

Although recent AEC publications<sup>62</sup> contain footnotes indicating that forward costs would not necessarily represent market prices, the distinction was never emphasized until prices began to rise far above the forward cost of \$8 to \$10 were normally thought of as the reserves that would be exploited in the medium term. In December 1975, the National Research Council of the National Academy of Sciences recommended that the forward cost system of reporting reserves be abandoned. The report says that the forward cost concept is inherently misleading and confusing and that forward costs are misinterpreted since forward costs do not represent the prices at which uranium will be marketed.<sup>63</sup>

This discussion should not be interpreted to mean that everyone in the nuclear industry was fooled into thinking that the forward cost figures associated with low cost reserves were representative of the long-run price of uranium oxide in an expanding market. On the contrary, many of those familiar with the economics of the supply sector perceived an inconsistency between expected supply and expected demand at the prices being quoted by government agencies, reactor vendors and utilities. We will discuss this further in the section below on uranium prices.

#### The Structure of the Uranium Industry

It is difficult to get good information on the structure of the uranium mining sector. The Census of Manufacturers does not report separate concentration ratio information for uranium mining. We do have information on uranium milling and since about 90 percent of all uranium reserves are owned or controlled by the millers, concentration ratios for the milling portion of the product stream should give us a fairly good upper bound estimate for the concentration ratios of the mining and milling sector as a whole. In Table 8

are reported four, eight and sixteen firm concentration ratios for the uranium milling capacity. Four and eight firm concentration ratios are on the moderate to high side relative to other primary energy industries.<sup>64</sup> It should be remembered, however, that since transportation costs for uranium concentrate are small relative to the value of the product transported, the relevant geographical market is a national market, whereas the relevant geographical market for uranium's chief substitute, coal, is probably a set of regional markets.<sup>65</sup> An examination of the concentration ratios alone would seem to put this industry in a gray area with regard to the potentials for competition. The industry has concentration ratios higher than those in industries that would be generally conceded to be vigorously competitive, but lower than in those industries that have been often cited for potential or actual antitrust abuse.<sup>66</sup> The structure of the industry, as measured by these concentration ratios, does not give us enough information by themselves to draw conclusions regarding the real or potential existence of oligopolistic pricing behavior. At least during the period 1969-1975 uranium mining and milling appears to have been quite unprofitable with many major firms achieving accounting losses. At least during this period of excess capacity (see below) there does not appear to have been sufficient market power to lead to price levels consistent with even positive profits. The ability to coordinate supply behavior so as to raise prices above competitive levels may be even more difficult today as import restrictions are lifted and firms in many other countries become eligible to sell uranium in the U.S.

The Uranium Market in the United States: 1948-1975

The uranium "market" can only be understood by viewing it in an historical context composed of several distinct historical periods.

1. 1948-1957: Vigorous expansion of the uranium industry in response to attractive payments offered by the AEC (the First Expansionary Period).
2. 1957-1962: Expansion ceases as the AEC receives deliveries on existing contracts but will no longer encourage expansion of the industry. Uranium deliveries peak, but exploratory and other expansionary activity comes to a virtual halt.
3. 1962-1969: A period of industry decline as the AEC purchases a reduced amount of uranium from reserves discovered prior to November 1958 at prices at or below \$8 per pound in order to keep some private uranium firms in business until commercial demand develops.
4. 1969-1973: A commercial market begins to develop but with serious inconsistencies between demand and supply expectations at prevailing prices. The market develops slowly and is characterized by continuing excess capacity and a failure of the uranium consuming sector to match long-term requirements with long-term supply contracts.
5. 1973-1975: The commercial market reaches maturity (the Second Expansionary Period). The demand side and the supply side of the market begin to come into balance as utilities go to the market to try to cover medium- and long-term requirements. Uranium prices rise dramatically.

Let us examine each period in detail.

1. 1948-1957: Period of Vigorous Expansion. The Atomic Energy Commission



was the only buyer of uranium during this period of time in the United States. Purchases were primarily for weapons acquisition and to provide material for government-owned plutonium producing and experimental reactors. At the beginning of this period there was essentially no domestic uranium industry. AEC requirements came from foreign sources, primarily Canada and the Belgian Congo. Beginning in 1948 the AEC set as one of its primary goals the rapid expansion and development of a domestic uranium mining and milling industry composed of privately held firms. To accomplish this goal, the AEC embarked on a program to purchase ore and contract for milling services at prices which would encourage private firms to enter the industry.

The AEC established a fixed minimum price schedule for the purchase of uranium ore of various qualities and provided firms with additional bonus payments for initial production of uranium, for development expenditures, and for the production of ore with  $U_3O_8$  contents of greater than .20 percent. The AEC also let participation contracts to encourage uranium exploration and paid for access roads to mining areas. The AEC ran the milling part of the supply stream something like a regulated utility. A prospective mill owner would have to apply to the AEC for a certificate of need. If granted, the AEC would sign a long-term (five to seven year) cost plus profit contract for the delivery of a specified quantity of  $U_3O_8$  over the contract period. The pricing procedure was favorable in a number of respects; in particular, rapid depreciation of mill plant and equipment was allowed.<sup>67</sup>

The result of the AEC policy was the rapid expansion of the mining and milling industry. By 1957<sup>24</sup> mills had either been built or were under construction with a capacity of over 21,000 tons of ore per day (about 18,000 tons of  $U_3O_8$  per year).<sup>68</sup>

2. 1957-1962: The Uranium Industry Reaches Its Peak in Terms of Production But Expansion is Halted by the AEC. In 1957 and 1958 the AEC began to change its policy regarding the expansion of the mining and milling industry. It was decided that it was no longer in the government's interest to encourage additional expansion of the industry.<sup>69</sup> Existing contractual arrangements running until March 1962 would be honored and ore purchased at the stipulated contract prices. No new contracts were to be signed for the period up to 1962 except under special circumstances. Beginning April 1, 1962, through December 31, 1966, the AEC would purchase not more than 500 tons  $U_3O_8$  per property at a fixed price of \$8.00 per pound. Reserves developed prior to November 1958 were the only ones eligible. Quantities beyond 500 tons might be purchased after negotiation but at prices below \$8 per pound. When the policy was announced in 1957, no purchases from new reserves were anticipated.

During this period the uranium industry reached its peak in terms of production and capacity (see Table 9). More uranium oxide was produced by the industry during 1961 and 1962 than has ever been produced subsequently (see Table 9). However, exploration activity peaked in 1957 and then began to decline in response to AEC policy (see Figure 1).

3. 1962-1968: The Uranium Industry Contracts. This period was a critical hiatus for the industry. No major new AEC contracts were let and deliveries to the AEC declined as old contracts had expired and the new "maintenance" contracts at low prices were signed. The AEC procurement policy was apparently designed to maintain some uranium mining and milling capacity in operation so that a base load industry would exist and be available for the commercial uranium requirements that were expected to begin to materialize at the end of the decade. The \$8 price was deemed sufficient to allow at least some of

the existing firms to continue operating rather than to encourage entry. As a result, the prices were set sufficiently high to cover at least the variable operating costs of at least some of the larger and more efficient mines and mills in the industry.

Many mines and mills closed during the period (see Table 5) as  $U_3O_8$  requirements declined and since the \$8 price combined with restricted orders led to losses for many of the smaller operations.<sup>70</sup> There was also substantial merger activity with the takeover of mining properties by the larger mills and the merging of companies engaged primarily in uranium mining and milling by larger companies engaged in the large minerals and fuels industries. The AEC also stretched out some of its 1962-1966 contractual arrangements until 1970 and agreed to purchase additional quantities of uranium at prices below \$8 to help keep some of the mills in business until a substantial commercial market developed. The first deliveries to commercial buyers began in 1967, but commercial purchases did not surpass even the meager AEC purchases until 1970 (see Table 10).

The uranium industry during this period of time had many of the characteristics of a declining industry. There were many exits of mines and mills, and exploratory activity declined dramatically (see Table 5 and Figure 1). Supply was provided by more intensive utilization of existing reserves rather than new reserves and the production from reserves with the lowest short-run costs of production. This behavior is reflected in the declining grade of ore mined beginning in 1963 (see Table 6) and the gradual shift away from high cost underground mines to low cost open pits mines (see Table 11). This latter movement occurred despite the fact that the majority of low cost uranium reserves (58 percent) were estimated to be located in deposits requiring underground mining.<sup>71</sup>

Drilling activity is very low through 1966 (see Figure 1) reflecting the declining nature of the industry. Beginning in 1967 there is a rapid upturn in exploratory drilling, and new commitments for milling capacity to come on line in the early 1970's. Given the supply lead times indicated previously, such activity was probably in anticipation of a large commercial market developing by 1973. This is consistent with AEC projections made in the late 1960's that there would be 48,000 MWe of nuclear capacity on line in 1973 and uranium requirements of 14-15,000 tons of  $U_3O_8$  by 1973.<sup>72</sup>

4. 1969-1973: A Commercial Uranium Market Develops. The first two years of the period witnessed vigorous exploratory activity and a large increment in milling capacity put into the construction stage. However, by 1970 a number of things became evident. First, the growth in nuclear power was not nearly as rapid as optimistic projections made three years earlier had indicated. Construction delays, technical problems, regulatory delays, etc., all slowed the nuclear program. Actual nuclear capacity in 1972 and 1973 was to be only half of what had been predicted. In response to reduced demand expectations drilling activity peaked in 1969 and did not reach an equivalent level until 1975.

Perhaps more importantly, by 1971 the uranium mining and milling industry began to argue that uranium prices were simply not high enough to attract new exploration, development, mine and mill investment.<sup>73</sup> The mine and mill operators were reluctant to sign long-term fixed price contracts because much of the requirements would have to come from reserves which have not been either developed or even discovered, and the cost of developing, building and operating these new facilities were highly uncertain.<sup>74</sup> But consumers of uranium were also reluctant to sign long-term contracts at open ended prices for at least two reasons. There remained great uncertainty as to the timing



of nuclear facility operating dates. There also appeared to be plenty of uranium around in the spot market for a price no higher than \$8 both because one large seller (Westinghouse) was willing to sell at such low prices and because until July 1973 the AEC was willing to sell from its stockpile at \$8 per pound. As a result many of the consumers did not attempt to secure firm long-term supply commitments. Actual delivery commitments fell well short of expected requirements for a period more than four or five years out. By 1972 the industry found itself in the peculiar position of facing expected demand growth for uranium of prodigious magnitudes while the supply side of the market was expanding very slowly. A number of commentators noted the growing gap between supply realities and demand expectations.<sup>75</sup> At least through 1972 this basic and obvious contradiction between supply and demand expectations remained largely ignored by the utility industry and the reactor vendors in terms of their willingness to cover their long-term requirements with long-term purchase contracts including "front end" money to help develop new supply facilities.<sup>76</sup> In response to this situation, exploratory drilling activity fell off dramatically in 1971 and 1972, and milling capacity peaks out in 1972 (see Figure 1 and Table 5).<sup>77</sup> Many remaining small mines went bankrupt or merged with only the large integrated firms remaining in the market.<sup>78</sup> Uranium prices in the market remain below even the \$8 that the AEC paid in the middle and late 1960's through 1973 despite the fact that a "market view" indicated a serious inconsistency between demand and supply expectations at prevailing prices.

5. 1973-1975: Demand and Supply Expectations Are Rationalized. This period begins with a profound inconsistency between demand expectations and supply expectations at prevailing prices for uranium. An agent evaluating the market

as a whole in 1972 should have seen clearly that one of three things was going to happen sometime soon. Demand expectations would be revised downward sufficiently to make additional supply expansion unnecessary (unlikely). The uranium supply industry was bluffing, and capacity expansion would begin quickly at prevailing market prices, and prevailing contractual arrangements, or the AEC would extend the termination date of sales from its stockpile at \$8 per pound beyond July 1, 1973 (also unlikely). The price of uranium would rise sufficiently to clear the market (very likely).<sup>79</sup> Before proceeding we therefore want to examine carefully the market behavior which allowed an inconsistency between demand and supply expectations to develop and persist through 1973.

The first thing to recognize about the uranium market of the early 1970's is that it was a very new market. Commercial sales of any appreciable amount did not develop until 1970. Since uranium had never been used as a fuel before, purchasers had virtually no experience with uranium, uranium prices or uranium contracts. While expected demands for uranium for the late 1970's were quite high, actual private consumption was very low in the period 1970 to 1972. Since the industry was in an excess supply situation, there was plenty of uranium around in the spot market at very low prices. Some uranium consumers seem to have expected uranium prices in the \$8 to \$10 range throughout the life cycle of the reactors under consideration. These expectations were based on a number of circumstances. Uranium prices had in fact been below \$8 per pound in nominal terms for nearly ten years. The AEC, on which the industry depended heavily during these early years, reported reserves and associated statistics for so-called \$8 and \$10 uranium which was generally interpreted as reflecting the price of uranium (see discussion above). Finally, Westinghouse, acting as a major buying agent, was signing fixed

price contracts for uranium at \$8 to \$10 per pound, reinforcing the expectations that the less knowledgeable agents in the market had.<sup>80</sup> Those buyers who in fact perceived the inconsistency between demand and supply expectations could simply sign a contract with Westinghouse to cover their medium-term uranium requirements. As a result, at least until late 1973, low price expectation were reinforced by a variety of factors, and demanders had little incentive to negotiate long-term open ended price contracts that a number of the suppliers were demanding.

On the supply side, the reluctance of suppliers who perceived the evolving inconsistency without firm delivery contracts with substantial escalation provisions is also understandable. The uranium industry had been extremely unprofitable throughout the late 1960's and early 1970's.<sup>81</sup> A number of firms which had engaged in vigorous exploratory activity and built additional mining and milling facilities in the late 1960's were badly "burned" as the expected uranium demands did not materialize. Existing firms were understandably cautious about bearing all of the risks of expanding supply given their recent experience, desiring instead to share the risks in some way with their utility customers.<sup>82</sup>

Uncertainties about demand were not the only factors causing reluctance on the part of potential suppliers to bear all of the risks of supply investments. The Atomic Energy Commission owned 50,000 tons of uranium, which if released to the market for sale at the then prevailing AEC price of \$8 would provide sufficient additional supply capacity to meet demand until the late 1970's and put an effective \$8 lid on prices until then. But by mid-1971 the AEC announced its "split-tails" policy as a method of disposing of its

uranium stockpile without putting it directly on the market eliminating this uncertainty. Another uncertainty on the supply side leading to reluctance to sign long-term contracts on the part of utilities was imports.<sup>83</sup> Throughout this period imports of uranium by commercial buyers was prohibited. It was not until late 1973 that the AEC announced its proposed import policy which would allow limited imports beginning in 1977 and would remove all restrictions by 1984.<sup>84</sup> Finally, one large supply intermediary, Westinghouse, itself was an important factor. Westinghouse had contracted to deliver for a very large proportion of the expected domestic uranium requirements (see Section IV below). As far as anyone knew, these requirements would be met by a combination of Westinghouse supply contracts and production from its own uranium reserves. Since Westinghouse did not reveal its short position until July 1975, both potential suppliers and potential demanders could have legitimately viewed this proportion of the market as "covered".

Under the circumstances it is understandable that supply agents would be reluctant to make investments in new capacity without some kind of contractual arrangements which at least share the risks with potential customers. Both because of weak incentives and general unfamiliarity with the overall market situation, utility customers did not show interest in either long-term contracts nor risk sharing arrangements. As a result the inconsistency between demand and supply expectations was created and persisted.

A number of things occurred from mid-1973 to 1975 that helped to close the gap between demand expectations and supply realities. These events combined to encourage many utilities to go to the market to try to cover their expected uranium requirements with long-term contracts. As firms began to



sign contracts for forward delivery of uranium, it soon became evident that existing capacity of the uranium mining and milling industry was insufficient to cover the industry's uranium needs for the period beginning in about 1980.<sup>85</sup> This situation was gradually revealed as existing capacity became fully committed, as many utilities could not obtain bids for uranium under fixed price contracting arrangements, and as it became evident that Westinghouse had substantial unfilled uranium commitments. The result was a rapid rise in uranium prices. The events which led to the rationalization of the inconsistencies between demand and supply expectations appear to be the following:

a. Change in AEC Enrichment Contract Criteria. In January 1973 the AEC announced a change in its enrichment contracting procedures. The AEC proposed that purchasers of its enrichment services would have to sign long-term (ten year) fixed commitments contracts for enrichment services. These contracts would have to be signed eight years in advance of initial enrichment service and included penalty clauses for changes in schedules. Although the AEC announced its proposed contracts at the beginning of the year, the new policy could not be final until Congressional hearings were held by the Joint Atomic Energy Committee (JAEC). Since AEC proposals had frequently been changed in the past as a result of opposition by segments of the industry during JAEC hearings, there remained great uncertainty about the nature of the AEC's contracting requirements and their timing until after approval was granted by the JAEC and contracts became available.<sup>86</sup> While there had been suggestions for changes in AEC enrichment contracts even prior to 1973 and while the discussion during 1973 indicated that some movement to long-term contracts would be forthcoming in the future, the contracts themselves were

not available in final form until September 1973 and none were signed until December 1973.

There is substantial evidence to indicate that the primary motivation of the AEC in changing its enrichment criteria was to create an environment which would encourage private industry to enter the enrichment market. The long-term contract was required because of the difficulties private firms would have in obtaining financing without substantial long-term commitments from utilities, which as in the uranium market itself, utilities had been reluctant to sign.<sup>87</sup> By requiring long-term contracts the AEC could make it clear that its own enrichment capacity was fully committed and provide a standard contracting format which would force utilities to reveal in the market their own long-term requirements and thus encourage private investment to meet it. In some sense the enrichment portion of the fuel cycle was in a situation similar to the mining and milling sector. It was evident that substantial additional capacity would be needed in the 1980's to meet demands, but private industry was not able or willing to make the substantial investments required without firm commitments from utilities. By changing to a long-term contract framework the AEC hoped that it was creating contracting institutions that would make it economically desirable for firms to begin to build private enrichment facilities.<sup>88</sup>

The effect of the long-term contracting requirements for enrichment services appears to have been to accelerate utility attempts to tie down uranium requirements that would go along with the enrichment contracts. The industry literature is filled with discussions beginning in late 1973, but especially during 1974, as fixed commitment enrichment contracts are signed, that the vigorous activity on the buying side is a result of utilities' attempts to

fill the uranium requirements associated with their long-term enrichment contracts rather than a response to increased demand for uranium or the oil embargo.<sup>89</sup> In short, the result of the change in enrichment contract criteria appears to have been a rapid movement to match up long-term enrichment contracts with long-term uranium supply contracts.

b. AEC Uranium Stockpile. By early 1972 the uncertainties regarding the disposition of the government's huge  $U_3O_8$  stockpile discussed above were eliminated. As a result the AEC would no longer act as an "overhang" on the market discouraging utilities from making long-term contracts in the hopes of getting cheap  $U_3O_8$  from the AEC. This factor should have given some encouragement to utilities to go into the private market to obtain uranium commitments and also relieved some of the uncertainty faced by the mining and milling sector.

c. The medium- and long-term supply problem appears to have been gradually revealed during 1973, 1974, and early 1975. While utilities were able to make fairly substantial foreign purchases for future delivery in 1974, the supply situation remained very tight. The industry literature of 1973 and 1974 is filled with discussions of rising prices and short capacity and increasing activity by uranium consumers to cover their requirements.<sup>90</sup>

d. Rumors of Westinghouse's short position apparently began circulating in the industry by early 1974,<sup>91</sup> but it was not until July 1975 that Westinghouse confirmed that it was indeed short and the large magnitude of that short position. On July 14, 1975, Westinghouse announced that it was short between 40 and 60 million pounds of uranium for the period 1978-1995. Outside estimates have put that short position at close to 70 million pounds of uranium concentrate. This amounted to somewhere between 25 percent and 100 percent

of total industry uncommitted uranium requirements (see Section IV below for alternative calculations) for the period around 1980 and made absolutely clear the extent to which firm long-term contracts fell below industry requirements. By this time the inconsistency between uranium requirements and supply capabilities at current prices had been revealed in the market and had led to substantial price increases (see discussion of prices below). Westinghouse's confirmation of its short position, especially its size, raised the possibility that there might be an absolute shortage of uranium for the period around 1980 due to lead time constraints on new mining and milling ventures.

e. The Arab Oil Embargo (October 1973). To the extent that the Arab oil embargo had an effect on the price of uranium, it must have been an indirect "marketing" effect rather than a direct effect increasing the expected demand for uranium oxide. The effect of the oil embargo and the rise in prices was probably psychological, making electricity producers more aware of the need to have an insured supply of fuels. Since many consumers were at the beginning of 1974 maintaining large short positions in uranium, the effect of their increased awareness of availability problems was to encourage them to go to the market to contract for future requirements. In other words, the Arab oil embargo's effect was to encourage uranium consumers to firm up their demand requirements by going to the market and trying to sign contracts for future delivery rather than to increase demand expectations.

To summarize, there appear to be four historical phases in the history of the uranium market in the United States;

1. 1948-1957: Vigorous expansion of the uranium industry in response to attractive payments schedule offered by the AEC (the First Expansionary



Period of the industry).

2. 1957-1962: Expansion ceases as the AEC receives deliveries on existing contracts but will no longer encourage expansion of the industry. Uranium deliveries peak, but exploratory and other expansionary activity comes to a virtual halt.
3. 1962-1969: A period of industry decline as the AEC purchases a reduced amount of uranium from reserves discovered prior to November 1958 at prices at or below \$8 per pound in order to keep some private uranium firms in business until commercial demand develops.
4. 1969-1973: A commercial market begins to develop but with serious inconsistencies between demand and supply expectations at prevailing prices. The market develops slowly and is characterized by continuing excess capacity and a failure of the uranium consuming sector to match long-term requirements with long-term supply contracts.
5. 1973-1975: The commercial market reaches maturity (the Second Expansionary Period of the industry). The demand side and the supply side of the market begin to come into balance as utilities go to the market to try to cover medium- and long-term requirements and purchasing mechanisms develop to match demand and supply better. Uranium prices rise dramatically.

#### The Behavior of Uranium Prices

The behavior of uranium prices is conveniently analyzed in terms of the historical periods that characterize the uranium industry (see Table 12). Since there was no private market for uranium prior to 1968, we can examine the prices paid for uranium concentrate by the AEC during the period 1950 to 1967. The years prior to 1958 show the highest AEC payments reflecting the prices that the AEC had to pay to attract private industry into uranium mining

and milling. Since there was in fact substantial entry into the industry, these prices must have been at least as high as those which would have to prevail in a competitive market in long-run equilibrium for similar long-term (seven years) contracts. The lower uranium prices in the late 1950's appear to reflect the latter year prices under old contracts combined with the \$8 price for new contracts signed after 1958.

Beginning in December 1968 we can get spot price quotations for uranium purchased in the private market. Through 1973 these prices remain well below those paid by the AEC previously and the price at which the AEC was willing to sell uranium until July 1973. These low prices, I believe, reflect the declining industry -- excess capacity nature of the uranium mining and milling industry at this time -- and therefore represent the short-run variable costs of producing uranium concentrate from existing facilities. They represent the short-run flow equilibrium of a natural resource market with excess short-run capacity in the absence of the required feedback mechanisms which would yield the appropriate long-run stock and flow equilibrium.<sup>93</sup> These prices are in line with the "low cost" reserves reported by the AEC forward cost reserve criterion which were what the AEC concentrated on for policy purposes. Given the excess capacity in the industry and substantial evidence that sufficient new capacity was not being added to meet expected demands in the late 1970's and early 1980's at prevailing prices, the then prevailing prices probably give a good feeling for the variable costs of uranium production but not the total long-run marginal costs or long-run prices reflecting both long-run production costs and "user" costs.

Uranium prices begin to rise in 1973. They increase about twenty percent during 1973 reflecting increased forward purchasing activity by utilities as well as rising labor and operating costs. But it is in 1974 that prices really begin to increase dramatically as the inconsistencies between supply and demand expectations are revealed in the market. Prices rise fifty percent during the first six months and another fifty percent during the second half of the year. I believe that this price rise reflects the events discussed above. First, the long-term contracts for enrichment that utilities begin to sign in December 1973 engendered increased buyer interest in the forward uranium market. Second, domestic suppliers appear to have largely withdrawn from the market in 1974 reflecting their response to prices rising faster than the rate of interest and the fact that proven reserves had been largely committed. Mining and milling companies appear to have been reluctant to sign what were then typical fixed price plus escalation contracts for reserves and milling capacity that had not as yet been developed. The tight domestic supply situation is evidenced by both the rapidly rising price for uranium and the fact that the vast majority of contracts signed by utilities during that period were with foreign suppliers.<sup>94</sup>

Prices continued their rapid rise in 1975. In March, Westinghouse acknowledged for the first time that it was short uranium, although it minimized the extent of its exposure.<sup>95</sup> By June 1975, just prior to Westinghouse's announcement of its huge short position, the price had risen to \$22 per pound, about double what it was a year earlier. In September, Westinghouse announced that it would not honor its contracts for uranium delivery beyond the uranium that it had itself already contracted for, and

by the end of December the spot price had risen to \$35 per pound. Between February 1975, just before Westinghouse first acknowledged its short position, and December 1975, the price of uranium doubled.

The price run-up in 1974 and 1975 appears to reflect the rationalization between demand expectations and supply expectations caused by a variety of factors encouraging firms to reveal and fill their long-term requirements by actually contracting with suppliers. If consumers of uranium had made timely medium- and long-term commitments with suppliers for uranium, prices would have begun to rise earlier and would have risen more gradually. It is also possible that prices would not have risen so far because timely additions of supply would have eliminated any possibility of a bottleneck around 1980.

Before proceeding with a more detailed discussion of Westinghouse's behavior in the market and the claim for a discharge under UCC 2-615, it is worth examining the uranium prices reported a bit more closely. A careful examination of the price series in Table 12 gives us some useful information. We know that the prices that the AEC paid during the first expansionary period (1950-1958) were at least high enough to encourage entry for the simple reason that there was substantial entry. Therefore, the first question to ask is how do the prices which we observed in the 1973-1975 period (which I have called the second expansionary period) compare with the prices the AEC paid during the first expansionary period? In column 2 of Table 12 I present deflated price data using the "structures" price index component of the GNP deflator. We can see that at least until the summer of 1975, when Westinghouse revealed its short position, real prices remained well within the range of prices paid by the AEC during the first expansionary period of the uranium industry. Even the post July 1975 prices are close to the range of prices



paid by the AEC.

But merely deflating for inflation is not enough. The average grade of ore mined has declined fairly substantially since the mid-1950's, implying an associated increase in the real cost per pound of yellowcake. The ore content in 1974 was only about 60 percent of the ore content during the early 1950's and only about 70 percent of the ore content in 1961. Part of this deterioration reflects the intensive mining of old reserves rather than long-run depletion of the uranium reserve stock. Nevertheless we expect some depletion to occur over time even if the industry is in long-run equilibrium. In columns 3, 4, and 5 of Table 12 I have, therefore, calculated equivalent price for 1973-1975 assuming 10, 20, and 30 percent depletion since the first expansionary period. Even for an assumption of ten percent depletion the equivalent real prices of uranium prior to July 1975 are well within the range of prices paid by the AEC during the first expansionary period. There are other adjustments in real costs that we could make, such as tightened radiation standards, increased mine safety standards, etc. But this is unnecessary to make the point that the real prices of uranium certainly in July 1975 and probably even in December were no higher and perhaps even somewhat lower than the prices the AEC paid to encourage entry into the industry.

#### IV. WESTINGHOUSE AND UCC 2-615

##### Westinghouse's Behavior in the Market

During the late 1960's and early 1970's Westinghouse offered to supply fuel for light water reactors in the U.S. and abroad. In general, Westinghouse offered a complete nuclear fuel system, including the reactor and steam generating system, initial fuel core and a variable number of reloads. Westinghouse also agreed to supply fuel reloads to several reactors supplied by other vendors. Westinghouse generally offered uranium fuel at a fixed base price plus some escalation. The escalation factor apparently reflected changes only in certain labor and materials cost indexes,<sup>96</sup> however, and was not directly geared to the market price of uranium oxide. The prices at which uranium was sold were in the range of \$8 to \$10 per pound. As of January 1, 1975, Westinghouse signed uranium contracts with 23 U.S. utilities and three foreign utilities involving 49 reactors, of which 11 were reactors supplied by other vendors.<sup>97</sup> As of January 1, 1975, it is estimated that Westinghouse had uranium oxide commitments of approximately 60,000 tons for the period 1975-1988 and contracts to purchase only 14,000 tons during that period plus an inventory of 6,000 to 7,000 tons.<sup>98</sup> This leaves a "short" position of about 40,000 tons (see Table 13), of which about 5,000 tons are associated with contracts which have full cost pass through provisions. In summary, as of January 1, 1975, Westinghouse had commitments to supply 60,000 tons of uranium but had only 20,000 tons either in hand or contracted for. This was a short position which Westinghouse refused to acknowledge until July 14, 1975, and which represented a rather large shock to a market which is presently producing about 13,000 tons per year and has capacity to produce between

18,000 and 20,000 tons per year.

It is fairly easy to understand why Westinghouse would have found it advantageous to act as a uranium agent for utilities buying its reactors as well as for others willing to buy fuel fabrication services. Nuclear energy was a new technology to the vast majority of the nation's utilities in the early 1970's. Since a commercial market for uranium really did not begin to develop until 1969 or 1970, there were very few individuals who had any expertise as uranium fuel buyers. The utilities themselves certainly had no expertise, and there was probably very little around to be bought. It was only natural, therefore, for Westinghouse, interested in marketing its reactor system, to act as a buying agent for utilities. By acting as an agent for several firms Westinghouse presumably could accumulate some expertise in dealing with suppliers, be able to make intelligent analyses of the market and pool risks associated with uncertainties over exactly when particular reactors would be operating. Utilities which might have been hesitant to go with nuclear technology because of ignorance about the uranium market and future prices might now be encouraged to do so once Westinghouse was willing to guarantee supply at a fixed price. So it made good commercial sense for Westinghouse to set itself up as an uranium buying agent. It might also have been a more efficient buying arrangement than having each utility develop fuel expertise on its own. The fact that utilities found the fixed price contracts to be attractive is also not surprising since it eliminated uncertainty at a relatively small premium and saved the utility the expense of searching and contracting for uranium.

But why Westinghouse would sign fixed price contracts without also securing associated uranium supplies is difficult to understand. There does not appear to have been very much room for speculative

profit in the uranium industry. It was generally acknowledged as early as 1971 that the direction of prices was upward and given that the industry in the 1970-1972 period still remained slack with prices just covering extraction costs, there could not have been any real possibility of Westinghouse profiting from a price break by going short. Yet by going short on fixed price contracts, Westinghouse opened itself up to the possibility of fantastic losses if uranium prices rose. So it appears that by going short Westinghouse exposed itself to the possibility of large losses with no possibility of speculative profits. At least at first glance, Westinghouse's policy of going short appears to be irrational. Westinghouse's chief competitor, General Electric, engaged in relatively little actual uranium contracting in its fuel fabrication agreements and does not find itself in a position as serious as Westinghouse.<sup>99</sup>

If Westinghouse's "short" policy was a conscious, rationally thought out policy, there are a number of things that might have helped lead to such a policy. Westinghouse might have hoped that the AEC would indeed release its stockpile of uranium to the market at \$8 per pound, providing sufficient supply at low prices for several years. Alternatively, Westinghouse might have hoped that once import restrictions were eliminated, cheap uranium could be obtained from foreign sources. Finally, it is possible that Westinghouse hoped to fill its remaining requirements from its own reserves. If Westinghouse's policy turned on these considerations, it was indeed a high risk policy. The traditional AEC concern for protecting the domestic mining and milling industry combined with vigorous opposition by the industry to the AEC's marketing its uranium stockpile made such an occurrence extremely unlikely. In any case this possibility was eliminated by December



1972. Similarly, a very rapid elimination of import controls was unlikely because of opposition from the domestic uranium industry. But perhaps more importantly, the assumption that foreign uranium would be either easily available or cheap is questionable. During this period of time Westinghouse was engaged in vigorous activity to sell its reactors in a number of foreign countries. Germany, Japan, Great Britain, France and other countries had fairly substantial nuclear programs under way by 1972, most of which would require uranium from foreign sources. In addition, as discussed above, a careful examination of the prices that the AEC had to pay during the first expansionary phase to encourage entry should alone have raised questions about the full economic cost of additional uranium mining and milling capacity. If Westinghouse's policy of signing fixed price contracts while remaining short was a conscious policy, it was a risky one with little prospect of large gains.

Given the extraordinary risk associated with Westinghouse's uranium policy, one must at least raise the possibility that it was not a well thought out corporate policy, but in part evolved by accident. Of the total of about 70,000 tons of uranium that Westinghouse committed itself to deliver between 1966 and January 1, 1975, it appears that nearly half was contracted for during 1973 and 1974.<sup>100</sup> It appears also that prior to 1973 Westinghouse had contracted for delivery of at least 15,000 tons and perhaps as much as 29,000 tons of  $U_3O_8$ .<sup>101</sup> This means that a substantial portion of Westinghouse's short position was accumulated during the two year period of 1973 and 1974. Apparently, Westinghouse contracted to deliver nearly as much uranium during these two years as it had during the past seven years. It may have simply been that Westinghouse was slow to cover its requirements and that it got caught when the prices began to rise rapidly

in 1974. The possibility that careful scrutiny of the uranium situation might not have been occurring is reinforced when we recognize that these are the same years in which Westinghouse was facing serious cash flow problems and a rather substantial reorganization of the company.<sup>102</sup>

Whatever the reasons for Westinghouse's marketing behavior, it had important implications for the uranium market as a whole. During the 1973 to 1974 period, Westinghouse was engaged in selling substantial quantities of uranium to U.S. utilities but not covering these sales with supply contracts. The 1973-1974 period was a critical time for the uranium mining and milling industry, because it was during this period that timely additions of capacity would be necessary to meet uranium requirements efficiently for the late 1970's and early 1980's. By "efficiently", I mean providing additional supply at minimum costs and averting a possible absolute supply constraint (a corner). Uranium supply from existing mines and mills and those under construction is somewhat elastic in that low grade ore can be mined and milled from existing reserves, but this increases the cost per pound of  $U_3O_8$  dramatically. Westinghouse's behavior exacerbated the failure of aggregate industry demand expectations to be matched by an associated supply response because Westinghouse appears to have been a very large part of the difference between "firm demand" and total aggregate "expected demand". Since Westinghouse was itself engaged in uranium exploration and processing activity and owned substantial amounts of land with potential uranium reserves, it was possible, prior to Westinghouse's announcement, that it itself would provide for its residual requirements. By failing to reveal its true requirements in the market by securing uranium, Westinghouse failed to give the necessary demand signals to get the market prices moving toward long-run equilibrium during 1973-1974 as would have

occurred if it had followed a policy of covering its requirements in a timely fashion. As a result, when Westinghouse suddenly announced that it was short 70 million pounds, the true gap between industry demand and supply was finally revealed. This revelation may have pushed uranium prices above the long-run equilibrium level reflecting the possibility that a minimum cost supply response to demand expectations was impossible by 1980. The extent to which Westinghouse may have distorted the market in this way depends on how large a part of the industry short position it has for the period around 1980. We turn to this question now.

In Tables 14, 15, and 16, I present three alternative measures for the proportion of the total gap between expected requirements and firm supply commitments that was accounted for by Westinghouse. In Table 14 I compare the reported unfilled requirements filed with the Atomic Energy Commission as of January 1, 1975. For the period 1979-1981 Westinghouse's short position is over 30 percent of the total short position for the industry. In Table 15 estimates are presented based on the difference between ERDA and NAC estimates of uranium requirements and reported commitments, without allowing for reallocation of total industry inventories (that is, looking only at flows for the industry but allowing Westinghouse to liquidate its own inventory). Based on the ERDA estimates, Westinghouse's share of total industry shorts varies between 55 percent and 24 percent for the period 1979-1981. Based on the NAC estimates (which I believe are too high), it varies between 16 percent and 26 percent. Table 16 uses the same data but allows for complete inventory liquidation by the industry. Since at least part of this inventory liquidation could occur only be transactions from parties with excess supply to those with shortages, this comparison overestimates Westinghouse's proportion of the shorts for years prior to total

liquidation of excess inventories. Based on the NAC projections, we get the same results as Table 15. Based on the ERDA projections, Westinghouse is fully 100 percent of the industry shorts in 1980 and 24 percent in 1981.

The results reported in Tables 14 and 15 are probably the most useful. They indicate that Westinghouse has a short position in the 1979-1971 period that might be as low as 20 percent of total industry shorts or as high as 40 percent. Either number is quite large for an industry that was already as early as 1972 acknowledged to be in a tight supply situation for the late 1970's and early 1980's. Since demand is very inelastic and since short-run supply of total industry demand above 18,000 pounds is also extremely inelastic, the gradual revelation that another 20 to 40 percent of uranium would in fact have to be supplied could easily have driven the price of uranium up substantially. Since the price of uranium was already being driven up as other uranium buyers were covering their position in 1973 and 1974, Westinghouse's sudden revelation no doubt expanded the extent that firm demand was pushing on medium-term supply capabilities. This kind of price response is not unique. In 1973 wheat prices rose dramatically when it was finally revealed that the Russians had purchased substantial quantities of wheat on the U.S. market.

If Westinghouse had made timely purchases of uranium to match its commitments and had not engaged in fixed price contracting that gave the impression to others in the industry that they could get all the uranium they needed at \$8 to \$10 per pound, prices for uranium would have begun to rise earlier than 1974 and probably would not have risen so far. If Westinghouse had contracted earlier, it would have become evident that additional supply would only have been forthcoming at higher prices, and these prices would have risen in the market. In addition, the supply sector would have had another two years to adjust capacity to meet demand efficiently. It



appears that Westinghouse's own buying behavior probably affected both the timing of the price rise and the levels to which prices finally rose.

Westinghouse's behavior appears to have had two types of undesirable effects on resource allocation in the nuclear energy industry:

1. By helping to give utilities the impression that uranium would be cheaper than it actually would be in long-run equilibrium (more on this below), it encouraged overinvestment in nuclear generating facilities.

While it is often stated that uranium prices have an insignificant impact on the overall economics of nuclear energy, Joskow and Baughman have shown that a doubling of uranium and enrichment costs would reduce installed nuclear capacity by 25 percent in 1995.<sup>103</sup> In addition, in a presentation before the Connecticut Public Utilities Control Authority one utility showed that the increased uranium price changed their decision to replace an oil-burning plant with a nuclear plant and delayed the need for the nuclear plant by two years.<sup>104</sup>

2. Westinghouse's behavior helped to distort the efficient feedback mechanisms that should have evolved to effectively link demand and supply expectations and lead to appropriate price responses and a timely and efficient response by the supply sector to expected uranium requirements. As a result uranium prices in the near and medium terms will probably be higher than they would have been with more timely additions to mining and milling capacity.

#### Westinghouse's Request for a Discharge Under UCC 2-615

Westinghouse seeks to be excused from its contractual obligations under UCC 2-615 on the grounds that the rise in uranium prices was caused by the Arab oil embargo and the subsequent rise in oil prices, that this event was unforeseeable, and that prices have increased so much that performance would

be commercially "impracticable".<sup>105</sup> In light of the discussion in Sections II and III, let us proceed to evaluate Westinghouse's position.

1. Failure of underlying condition of the contract must occur. Presumably the underlying condition that failed was the assumption that the oil embargo and the subsequent use in oil prices which then led to a rise in uranium prices would not occur. Westinghouse does not appear to meet this requirement, because the only way the rise in oil prices could have affected uranium prices would have been by increasing uranium demand expectations through an increase in nuclear generating capacity. But I have argued above that for a variety of reasons demand expectations for nuclear generating capacity in the U.S. through the early 1990's have fallen almost continuously since 1970 and continued to fall after 1973. In addition, foreign expectations have declined since 1973 as well. Any effect that oil prices alone might have had on nuclear generating capacity has been overwhelmed by other factors.

While the "OPEC argument" does not appear valid, let us be charitable and allow that the change in enrichment criteria and problems with reprocessing and plutonium recycling might also be failures of underlying conditions. But even when these factors are taken into account, expected uranium requirements have certainly not increased since 1973, at least for the period through the 1980's.

It appears that the only underlying condition that Westinghouse might reasonably claim has failed would revolve around the argument that uranium suppliers have successfully cartelized the industry and artificially raised prices. While I find this doubtful, the proper remedy would be through a private antitrust action and not UCC 2-615.

2. The failure must have been unforeseeable at the time the contract was signed. Since the "OPEC" argument" does not appear to satisfy the "failure" requirement, I will not try to argue whether it was foreseen or foreseeable. In any case, in a recent federal court opinion the court held that the events in the Middle East, at least as of 1972, were sufficiently "foreseeable" that sophisticated agents should have included the possibilities of increased prices and supply interruptions in the terms of their contracts.<sup>106</sup>

Under the circumstances let us allow a broader interpretation and ask whether a rise in uranium prices, given prevailing expectations prior to 1974, was either foreseen or foreseeable. I have already argued that an examination of the demand projections and the commitments the supply sector was making for future capacity were obviously inconsistent with one another in 1972 and 1973 for the period beginning around 1979 and 1980, given the lead times required to bring on additional mining and milling capacity, unless one believed both that the AEC would dump its stockpile on the market and that all import restrictions would be completely and rapidly eliminated and substantial amounts of low cost uranium made available from foreign sources. This inconsistency was apparently recognized by many in the industry. Numerous people familiar with the uranium industry indicated that the supply picture and the demand picture would only be brought into balance if prices rose and government policy regarding the disposition of  $U_3O_8$  stock and imports was cleared up.<sup>107</sup> Some people predicted a price rise while others just spoke about tight markets developing throughout the 1972-1973 period. Since we cannot assume that all of the commentators were well trained in economics, it is not at all strange that some planners spoke of the tight market in terms of an emerging gap between quantities required and supply capabilities at prevailing prices without translating this into the need for a price increase. The question of actual

price estimation required a detailed understanding of the costs of bringing on new supply and the timing of that supply, both of which were highly uncertain. That something had to give, whether it was price or demand, was, I think, very clear by the beginning of 1973 and perhaps earlier from an examination of the inconsistencies between demand projections and plans for additional capacity. But a careful examination of the price data for uranium transactions gives us even more reason to believe that well informed entrepreneurs should have expected prices to rise once the industry moved out of an excess capacity situation.

In the discussion above we indicated that prior to July 1975 real prices of uranium were generally below the prices prevailing in the 1950's, when there was substantial entry into the industry. That prices would have to rise to such levels once again to encourage entry into the industry would only be surprising if one believed that the AEC paid prices far above what was really necessary to encourage entry or that there had been important cost reducing technological change. There does not appear to be any evidence for either proposition and, if anything, tightening mining criteria and reserve depletion have probably raised the real costs of uranium extraction. A buyer could, of course, have easily been fooled if he only looked at prevailing market prices and AEC "cost" estimates in making his price expectations. Uranium prices were indeed low for many years, reflecting the excess capacity in the uranium industry. The forward cost system did give misleading information about possible future uranium prices unless used correctly. Westinghouse was willing to supply all comers at prices between \$8 and \$10 per pound. But one would have thought that a large buyer in the market, like Westinghouse, would have been more than a naive price taker and would have done a more sophisticated analysis of price



formation in the uranium market. After all, Westinghouse did commit itself to deliver about 140 million pounds of uranium. Westinghouse had an additional advantage; it knew that a large part of this commitment had not been contracted for and that Westinghouse itself represented a huge hidden future demand on the market. A price rise of some size was foreseen by many in the industry and should reasonably have been foreseeable by perhaps the largest agent in the market, Westinghouse. I have been able to find no evidence indicating that Westinghouse had, prior to late 1973, performed an extensive analysis of uranium price behavior over the life of its contracts. Perhaps if it had conducted such analyses, as it should have, it would have been much more reluctant to sign the kinds of contracts that it did.

All things considered, it does not appear that Westinghouse satisfies the "foreseeability" requirement either. To hold otherwise would encourage suboptimal use of available information and the introduction of incorrect price information into the process of exchange.

3. The risk of failure must not have been assumed either directly or indirectly by the party seeking excuse. Recall that Comment 8 to UCC 2-615 indicates that the allocation of risk to the party seeking excuse may be found in the circumstances surrounding the contract as well as in the terms of the contract. But the reason for many of the contracts was to convince utilities to buy reactors from Westinghouse by performing a role as uranium buying agent insuring them against fluctuations in the price of uranium. Why would somebody buy a long-term fixed price contract other than to insure against fluctuations in the price of uranium? The general commercial reasons for signing long-term fixed price commodity contracts seems to preclude excuse under 2-615 simply because the nature of this kind of commodity contract implies the assumption of the risk of price fluctuations

on the seller. The inherent uncertainties within the uranium market itself associated with enrichment, reprocessing and recycling, foreign imports, etc., were the reasons why utilities were attracted by the fixed price contracts. To hold that the risks of such uncertainties were not implicitly or explicitly to be borne by the seller seems to be inconsistent with the intent and good sense of this requirement under UCC 2-615.

4. Performance must be impracticable. Even assuming that Westinghouse satisfied the first three requirements, its case based on "impracticability" due to the rise in costs is still unclear. The three- to fourfold increase in prices is larger than the doubling, which clearly is not sufficient, and smaller than the ten- to twelvefold increase that has been mentioned as being clearly enough.<sup>108</sup> But to complicate the matter even more, many of Westinghouse's uranium contracts were written in conjunction with reactor contracts. If we were to consider the total value of the contract, including perhaps hundreds of millions of dollars for the NSSS and other components, the increase in the cost of uranium would add a much smaller proportionate cost to the total contract. Whether Westinghouse satisfies even the impracticability test is at best questionable.

5. The party claiming excuse must do everything possible to insure itself of an adequate source of supply. Westinghouse's problem arises from the fact that it was short over 67 percent of its uranium commitments. It could have covered these shorts in a timely fashion by purchasing  $U_3O_8$  forward when it signed the sales contracts or by developing its own reserves more quickly. Westinghouse gambled that its requirements could alternatively be obtained from the market at a favorable price. It gambled (either consciously or unconsciously) and lost. Westinghouse could have covered its requirements by obtaining long-term supply commitments as it made sales of

uranium. In fact, if it had engaged in more timely contracting, market prices would have begun to rise more quickly as the market moved to a long-run equilibrium. Westinghouse would probably have realized sooner that the fixed price contracts it was signing would be unprofitable. The common law cases underlying UCC 2-615 and subsequent cases under it cited above<sup>109</sup> quite clearly indicate that under these circumstances a discharge will not be granted and that for reasons of economic efficiency such behavior should not be encouraged by the contract law itself.

6. The seller must not by his own actions create the event causing the impracticability of performance. Finally, it was argued above that Westinghouse's own behavior in the market had important effects on both the time pattern of prices and the levels to which prices have now risen. More timely contracting on Westinghouse's part would have led to an earlier supply response and ameliorated supply bottlenecks around 1980. By keeping its requirements secret for so long and not "revealing" them to the market by contracting for supplies, Westinghouse was a major contributor to the failure of standard feedback mechanisms to signal the movement into a new expansionary phase for the uranium supply sector. Westinghouse certainly fails to meet this wise requirement of the common law that has for some reason been omitted from UCC 2-615.

The discussion in Section II concluded that the intent and current interpretations of UCC 2-615 makes good sense in terms of its ability to promote efficient bilateral exchange, by facilitating the contracting processes and by providing useful guidance around the difficulties of exchange agreements, and to protect poorly represented individuals. At least as currently interpreted, Westinghouse appears to fail on all counts to justify a discharge of its contractual obligations under UCC 2-615.

To hold otherwise would mean a major change in the interpretation of the impracticability doctrine, serving to shift business risks ordinarily borne by the sellers of the commodity to the buyers. The long-term effects of such a decision would be to increase uncertainty in contractual relationships involving an associated increase in transactions costs and impairment of efficient market mechanisms. The increase in transactions costs would accompany both the increased uncertainty associated with contracts of this type as well as give disincentives to sellers to use the information available to them to predict the likely course of commodity prices, to insure against price fluctuations by including appropriate price adjustment mechanisms in contracts, and to adopt efficient procurement policies. Buyers can, of course, adapt to such behavior by sellers, but generally only through procedures which will increase the costs of exchange.<sup>110</sup> Finally, a decision in favor of Westinghouse would increase the uncertainty associated with UCC 2-615 itself, leading at least in the short run to a substantial increase in litigation and delays in performance on contracts. Neither economic efficiency nor justice would be served by finding for Westinghouse.



TABLE 1

PROJECTIONS OF NUCLEAR CAPACITY

	<u>GWe</u>	
	<u>1985</u>	<u>1995</u>
AEC 1970 <sup>1</sup>	300	---
AEC 1971 <sup>1</sup>	(254-321)	---
AEC 1972 <sup>2</sup>	231-275	602-972
AEC 1974 <sup>3</sup>	256-332	620-960
FEA 1974 <sup>4</sup>	204	---
ERDA 1975 <sup>5</sup>	160-245	445-790
Baughman-Joskow (75) <sup>6</sup>	190	552
FEA (76) <sup>7</sup>	142	---

Sources:

- <sup>1</sup> USAEC, WASH-1139 (70), p. 1, and WASH-1139 (Rev. 1), p. 2.
- <sup>2</sup> USAEC, WASH-1139 (72), p. 1 and p. 3.
- <sup>3</sup> USAEC, WASH-1139 (74), p. 2 and p. 8.
- <sup>4</sup> Federal Energy Administration, Project Independence Report, November 1974, p. 127.
- <sup>5</sup> Energy Research and Development Administration, unpublished projections, February 1975.
- <sup>6</sup> Joskow and Baughman, "The Future of the U.S. Nuclear Energy Industry", Bell Journal of Economics, Spring 1976, p. 19. (Base case)
- <sup>7</sup> Federal Energy Administration, 1976 National Energy Outlook, February 1976, p. 36.

TABLE 2

ESTIMATED ANNUAL URANIUM REQUIREMENTS

Tons  $U_3O_8$

AEC -- ERDA

	<u>1/1/73</u>	<u>1/1/74</u>	<u>1/1/75</u>	<u>8/1/75</u>	<u>NAC</u> <u>7/1/75</u>
1973	9,100				
1974	12,500	9,700			
1975	16,500	11,700	10,800	8,500	10,154
1976	19,200	12,600	14,100	9,600	12,678
1977	21,700	16,000	17,500	16,400	19,049
1978	26,800	19,800	20,500	20,800	27,258
1979	31,200	25,200	23,200	22,700	31,627
1980	34,600	31,500	25,800	28,500	40,645
1981	39,900	35,000	30,800	35,700	46,086
1982	44,700	37,500	37,700	34,600	41,989
1983	50,400	39,800	41,800	37,600	42,041
1984	57,000	48,000	46,100	38,000	49,839
1985	64,500	57,200	50,900	37,000	52,635

Source: Kidder, Peabody Report, pp. 23-24.

TABLE 3

URANIUM DELIVERY COMMITMENTS

Annual Tons U<sub>3</sub>O<sub>8</sub>

	as of <sup>1</sup> <u>Jan. 1, 1974*</u>	as of Jan. 1, 1975		
		<u>*</u>	<u>**</u>	<u>Total<sup>2</sup></u>
1973	12,100			
1974	13,700	11,900		11,900
1975	15,500	15,600	800	16,400
1976	10,900	12,600	1,500	14,100
1977	11,600	12,700	2,600	15,300
1978	13,200	15,300	3,100	18,400
1979	12,100	13,900	3,000	16,900
1980	10,200	11,600	2,700	14,300
1981	7,700	10,400	3,500	13,900
1982	6,600	8,800	3,700	12,500
1983	5,900	7,100	3,600	10,700
1984	4,000	4,500	3,600	8,100
1985	3,400	4,100	3,400	7,500
1986	1,700	1,900	2,300	4,200
1987-1994	<1,000	<1,200/year	<2,000/year	<3,200/year

\*Domestic sellers to domestic buyers.

\*\*Imports

<sup>1</sup> USAEC, WASH-1196 (74), April 1974, p. 4.

<sup>2</sup> USERDA, ERDA-24, April 1975, pp. 4 and 8.

Inventory January 1, 1974: 19,900  
Normal desired inventory of at least three months

TABLE 4

REPORTED UNFILLED URANIUM REQUIREMENTS

Tons U<sub>3</sub>O<sub>8</sub>

	<u>Total Reported by Utilities and Vendors</u>		<u>Reported Unfilled Requirements as a Proportion of Expected Requirements</u>	
	<u>1/1/74<sup>1</sup></u>	<u>1/1/75<sup>2</sup></u>	<u>1/1/74<sup>3</sup> -- %</u>	<u>1/1/75<sup>4</sup> -- %</u>
1974	100	0	0	--
1975	200	0	2	0
1976	600	1,000	5	7
1977	1,500	1,400	9	8
1978	5,100	6,600	26	32
1979	9,300	11,500	37	50
1980	15,300	18,800	49	60
1981	N/A	18,700	--	61
1982	N/A	22,500	--	60

<sup>1</sup> USAEC, WASH-1196 (74), April 1974, p. 13.

<sup>2</sup> USERDA, ERDA 24, April 1975, p. 13.

<sup>3</sup> Based on Column 2, Table 2.

<sup>4</sup> Based on Column 3, Table 2.



TABLE 5

URANIUM MILLING CAPACITY 1957-1975

	<u>Number of Mills Operating</u> (Yearend)	<u>Capacity*</u> (Tons of ore per day)
1957	16	11,000
1958	23	21,000
1959	24	22,000
1960	25	22,300
1961	26	22,500
1962	24	22,000
1963	21	N/A
1964	20	N/A
1965	16	N/A
1966	17	N/A
1967	16	N/A
1968	13	N/A
1969	15	23,450
1970	15	26,450
1971	17	27,500
1972	20	31,900
1973	18	28,450
1974	14	25,450
1975	15	23,000

\* Unfortunately, estimates of  $U_3O_8$  production capacity is reported for only a few years. The relationship between column 2 and yellowcake capacity depends on the ore grade of the rock and the amount of ore left in the rock by the particular process used. In 1972 yellowcake production capacity was estimated at 19,000 tons per year and at 18,000 tons per year in 1973. For 1970 and 1971 it was estimated at 15,000 to 16,000 tons per year. Since mills operated near full capacity through 1962, the figures given in Table 10 for deliveries to the AEC are probably close to the capacity levels of the mills.

Source: 1957-1973, Minerals Yearbook (Uranium Chapter).  
1974, USAEC, GJO(100-75), p. 80.  
1975, USERDA, GJO(100-76), p. 80.

TABLE 6

AVERAGE  $U_3O_8$  CONCENTRATION OF ORE DELIVERED

---

	<u>%</u>
1951	0.31
1952	0.32
1953	0.31
1954	0.32
1955	0.30
1956	0.28
1957	0.28
1958	0.27
1959	0.26
1960	0.24
1961	0.24
1962	0.24
1963	0.25
1964	0.25
1965	0.24
1966	0.23
1967	0.20
1968	0.195
1969	0.21
1970	0.20
1971	0.20
1972	0.21
1973	0.21
1974	0.18
1975	0.17

Source:

1951-1971: U.S. Bureau of Mines, Minerals Yearbook, vol. I, 1959-1971 (Chapter on Uranium).

1972-1975: USERDA, Statistical Data of the Uranium Industry, January, 1, 1976, p. 86.

TABLE 7

AVERAGE DEPTH OF EXPLORATORY HOLES DRILLED

(Feet)

1958	148
1959	146
1960	191
1961	160
1962	230
1963	104
1964	162
1965	187
1966	313
1967	425
1968	422
1969	428
1970	409
1971	401
1972	439
1973	480
1974	580
1975	482

Source: USERDA, Statistical Data of the Uranium Industry,  
January 1, 1976, p. 56.

TABLE 8

CONCENTRATION LEVELS IN URANIUM MILLING

Percent of Capacity  
(tons of processed ore)

	<u>1967</u>	<u>1971</u>
four firms	57.0	54.4
eight firms	78.7	78.5
sixteen firms	100.0	99.8

Source: Competition in the U.S. Energy Industry, Duchesneau,  
p. 88.



TABLE 9

U<sub>3</sub>O<sub>8</sub> RECEIPTS BY DOMESTIC MILLS

	<u>Tons U<sub>3</sub>O<sub>8</sub></u>
1950	810
1951	1,088
1952	1,288
1953	2,315
1954	3,539
1955	4,425
1956	8,434
1957	9,837
1958	14,003
1959	17,377
1960	18,842
1961	18,513
1962	17,085
1963	14,721
1964	13,881
1965	10,578
1966	10,051
1967	10,866
1968	12,850
1969	12,595
1970	13,037
1971	13,089
1972	13,863
1973	13,787
1974	12,400
1975	12,000

Source:

1950-1973: USAEC, Statistical Data of the Uranium Industry,  
January 1, 1974, p. 7.

1974-1975: USERDA, Statistical Data of the Uranium Industry,  
January 1, 1976, p. 10.

TABLE 10

DELIVERIES OF  $U_3O_8$  FROM DOMESTIC MILLS

Tons  $U_3O_8$

	<u>To AEC</u>	<u>To Commerical Buyers</u>
1950	323	
1951	639	
1952	824	
1953	968	
1954	1,435	
1955	2,125	
1956	4,179	
1957	7,505	
1958	10,708	
1959	15,029	
1960	16,394	
1961	17,646	
1962	17,244	
1963	15,752	
1964	12,607	
1965	11,240	
1966	10,178	
1967	8,902	900
1968	7,937	4,800
1969	7,124	4,200
1970	4,010	9,300
1971	1,295	12,700
1972	--	11,600
1973	--	12,100
1974	--	11,900
1975	--	12,500

Source: USERDA, Statistical Data on the Uranium Industry,  
January 1, 1976, pp. 11 and 78.

TABLE 11

PROPORTIONS OF  $U_3O_8$  PRODUCTION FROM OPEN PIT

---

AND UNDERGROUND MINES

	<u>%</u>	
	<u>Open Pit</u>	<u>Underground</u>
1951	16%	84%
1952	21	79
1953	25	75
1954	26	74
1955	19	81
1956	38	62
1957	34	66
1958	39	61
1959	25	75
1960	28	72
1961	28	72
1962	25	75
1963	30	70
1964	24	76
1965	29	71
1966	31	69
1967	30	70
1968	37	63
1969	42	58
1970	46	54
1971	54	46
1972	59	41
1973	63	37
1974	59	41
1975	56	44

Source: USERDA, Statistical Data of the Uranium Industry,  
January 1, 1976, p. 26.

TABLE 12

Average Uranium Prices Per Pound  $U_3O_8$

	(1) \$	(2) \$	(3) \$	(4) \$	(5) \$
1950	9.21	12.63			
1951	10.01	12.62			
1952	11.19	13.45			
1953	12.30	14.49			
1954	12.25	14.24			
1955	12.51	14.20			
1956	11.63	12.45			
1957	10.53	10.68			
1958	9.57	9.57			
1959	9.25	9.01			
1960	8.75	8.41			
1961	8.47	8.02			
1962	8.00				
1963	8.00				
1964	8.00				
1965	8.00				
1966	8.00				
1967	8.00				
12/31/68	6.50				
12/31/69	6.20				
12/31/70	6.20				
12/31/71	5.95				
12/31/72	5.95				
6/73	6.50	3.57	3.21	2.86	2.50
12/73	7.00	3.72	3.35	2.98	2.60
6/74	10.50	5.25	4.73	4.20	3.68
12/74	15.00	7.08	6.37	5.66	4.90
5/75	21.00	9.63	8.67	7.70	6.70
8/75	26.00	11.87	10.68	9.50	8.30
12/75	35.00	15.84	14.26	12.67	11.00

(1) Nominal Price Per Pound  $U_3O_8$

(a) 1950-1967 AEC purchases (U.S. ERDA, Statistical Data on the Uranium Industry, January 1, 1976, p. 11.)

(b) 1968-1975 Spot Market Price (NUEXCO Reports)

(2) Real Prices Deflated by GNP Structures Index

(3) Equivalent Real Prices Adjusted for 10% Depletion

(4) Equivalent Real Prices Adjusted for 20% Depletion

(5) Equivalent Real Prices Adjusted for 30% Depletion



TABLE 13

WESTINGHOUSE POSITION IN URANIUM MARKET<sup>1</sup>

as of January 1, 1975

Westinghouse Commitments 1975-1988:	60,084 tons U <sub>3</sub> O <sub>8</sub>
Westinghouse Inventory Jan. 1, 1975:	5,896 tons U <sub>3</sub> O <sub>8</sub>
Westinghouse Purchase Agreements 1975-1988:	<u>14,075 tons U<sub>3</sub>O<sub>8</sub></u>
Westinghouse Short 1975-1988:	40,113 tons U <sub>3</sub> O <sub>8</sub>

In addition General Electric is short 5,000 tons for the period 1982-1984.

<sup>1</sup> Kidder, Peabody Report, p. 8.

TABLE 14

WESTINGHOUSE'S SHARE OF UNFILLED URANIUM REQUIREMENTS

Tons U<sub>3</sub>O<sub>8</sub>

	<u>Total Reported by Utilities and Vendors</u>		<u>Westinghouse Short*</u>	
	<u>1/1/74</u>	<u>1/1/75</u>	<u>1/1/75</u>	<u>as % of Total**</u>
1974	100	0	0	--
1975	200	0	0	--
1976	600	1,000	0	0
1977	1,500	1,400	0	0
1978	5,100	6,600	0	0
1979	9,300	11,500	3,199	28%
1980	15,300	18,800	6,768	36%
1981	N/A	18,700	5,302	28%
1982	N/A	22,500	4,930	22%

\*Includes liquidation of 4,800 tons of Westinghouse's 5,900 ton inventory on 1/1/75.

\*\*This assumes that Westinghouse accurately reported its own short position in the AEC survey.

Source: Table 4 and Kidder, Peabody Report, p. 8.

TABLE 15

DERIVED UNFILLED REQUIREMENTS

(Without Inventory Liquidation by Industry)\*

Tons U<sub>3</sub>O<sub>8</sub>

		<u>Westinghouse</u>			
<u>ERDA (8/1/75)</u>	<u>NAC (7/1/75)</u>	<u>tons</u>	<u>% ERDA</u>	<u>% NAC</u>	
1977	1,100	3,749	0	0	0
1978	2,400	8,858	0	0	0
1979	5,800	14,727	3,199	55%	22%
1980	14,200	26,345	6,768	48%	26%
1981	21,800	32,186	5,302	24%	16%
1982	22,100	29,489	4,930	22%	17%
1983	26,900	31,341	4,169	15%	13%
1984	29,900	41,739	3,983	13%	10%
1985	32,800	48,435	3,777	12%	8%

\*Westinghouse is assumed to run down its inventory to 1,100 tons. Inventory for the rest of the industry is not liquidated.

TABLE 16

DERIVED UNFILLED REQUIREMENTS

(With Inventory Liquidation)\*

Tons U<sub>3</sub>O<sub>8</sub>

	<u>ERDA (8/1/75)</u>	<u>NAC (7/1/75)</u>	<u>Westinghouse</u>		
			<u>tons</u>	<u>% ERDA</u>	<u>% NAC</u>
1975	0	0	0	--	--
1976	0	0	0	--	--
1977	0	0	0	--	--
1978	0	0	0	--	--
1979	0	14,727	3,199	100%	22%
1980	5,496	26,345	6,768	100%	26%
1981	21,800	32,186	5,302	24%	16%
1982	22,100	29,489	4,930	22%	17%
1983	26,900	31,341	4,169	15%	13%
1984	29,900	41,739	3,983	13%	10%
1985	32,800	48,435	3,777	12%	8%

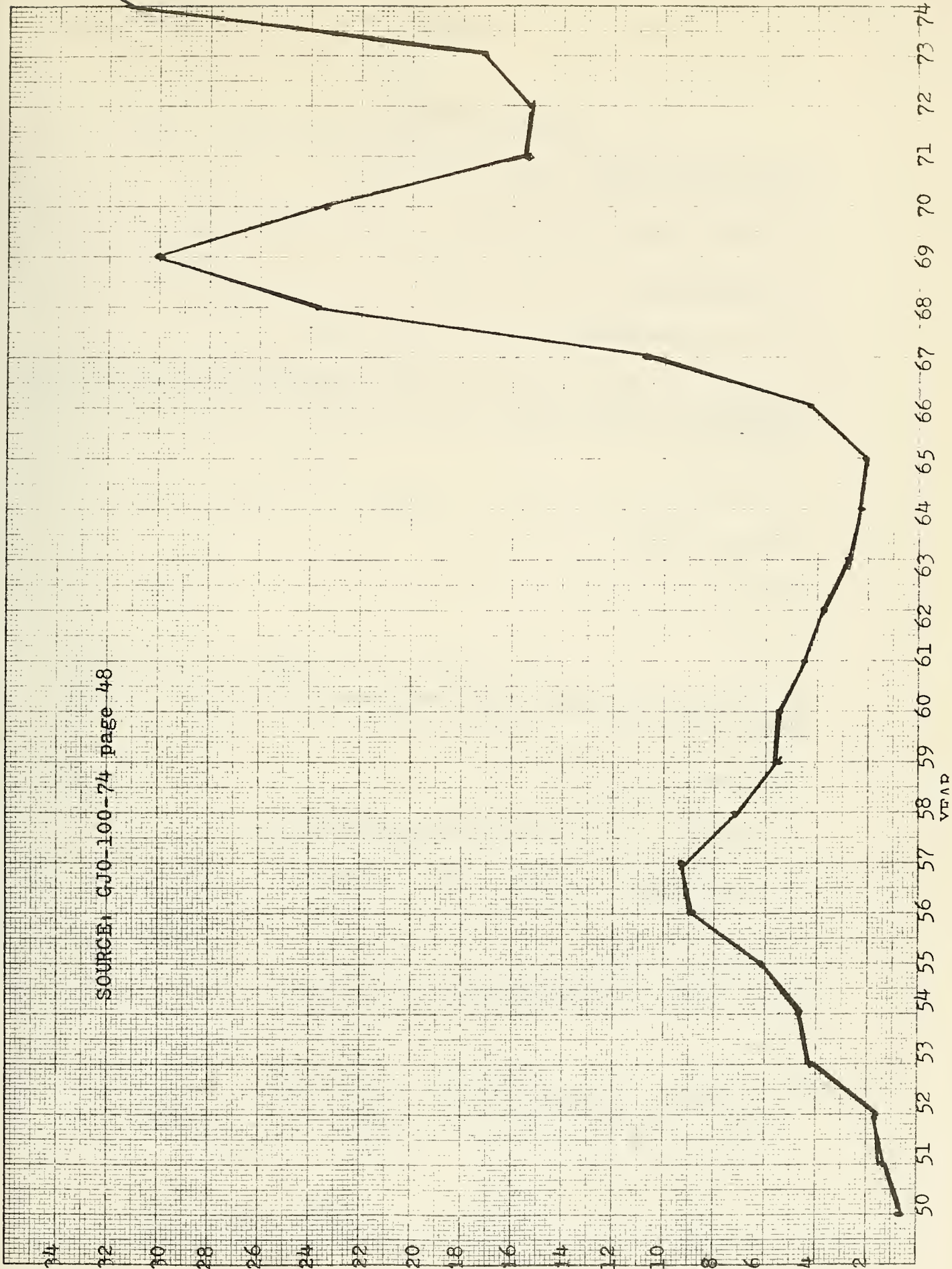
\*Assumes inventory of 1/3 annual requirements maintained.



SURFACE DRILLING: WESTERN U.S. 1950-1975

SOURCE: CJO-100-74 page 48

MILLIONS OF FEET DRILLED PER YEAR



FOOTNOTES

- <sup>1</sup> Wall Street Journal, July 15, 1975, p. 2.
- <sup>2</sup> Kidder, Peabody Report, p. 3.
- <sup>3</sup> Nucleonics Week, December 18, 1975.
- <sup>4</sup> See Joskow and Baughman.
- <sup>5</sup> Arrow, p. 4, suggests that the feedback mechanisms that result in price adjustment reflecting changing supply and demand situation are not well understood.
- <sup>6</sup> Posner, p. 42.
- <sup>7</sup> Posner, p. 44.
- <sup>8</sup> Ibid.
- <sup>9</sup> Ibid.
- <sup>10</sup> See Williams vs. Walker-Thomas Furniture Company, 350 F. 2 d 445 and Spanogle.
- <sup>11</sup> See Posner, pp. 44-55.
- <sup>12</sup> See Hurst, p. 549, and Paradine vs. Jane Aleyn (1647, K.B.).
- <sup>13</sup> In the Queens Bench, 1863, 3 Best S. 826.
- <sup>14</sup> 2 K.B. 740 (1903).
- <sup>15</sup> 172 Cal 289, 156, p. 458 (1916)
- <sup>16</sup> Hurst, p. 551.
- <sup>17</sup> Restatement of Contracts, (1932), Sections 458-461.
- <sup>18</sup> Ibid., Section 288.

<sup>19</sup> See Corbin, p. 1088, and UCC 2-613 through 2-616.

<sup>20</sup> Corbin, p. 1089.

<sup>21</sup> Ibid., p. 1090.

<sup>22</sup> Ibid., pp. 1100-1101.

<sup>23</sup> Hurst, p. 555 and Corbin, p. 1101.

<sup>24</sup> Corbin, p. 1111.

<sup>25</sup> 79 Com.L.J. 75, 77 (1974).

<sup>26</sup> 25 Cal 2d 48, 153, p. 2 & 47 (1944).

<sup>27</sup> Hurst, p. 567.

<sup>28</sup> Ibid., p. 570

<sup>29</sup> Restatement of Contracts (1932), Section 46.

<sup>30</sup> Hurst, pp. 563-564.

<sup>31</sup> Ibid.

<sup>32</sup> 258 N.Y. 194, 179 N.E. 383, 80 A.L.R. 1173 (1932).

<sup>33</sup> 4 UCC Rep. Serv. 1164 (1967).

<sup>34</sup> 381 F. Supp. 245.

<sup>35</sup> Corbin, pp. 1105-1106, and Martin vs. Star Publishing Co., 126 A. 2 & 238 (1956).

<sup>36</sup> See Williamson, pp. 4-7.

<sup>37</sup> Simon, p. 198.

<sup>38</sup> Williamson, pp. 65-67.

- 39 Arrow, pp. 4-8.
- 40 Arrow, pp. 4-8.
- 41 Solow, p. 6.
- 42 Joskow and Rozanski.
- 43 See Nuclear Engineering International, December 1975, p. 1016.
- 44 Official government forecasts of a number of countries for 1985 appear to be unrealistically high. Japan forecasts 49GWe while a value of 30-35 GWe is more realistic. Germany forecasts 40-45 GWe with a more realistic estimate being 30 GWe. France forecasts 50-55 with a more realistic estimate being 40-45. Italy forecasts 20-25 GWe with a more realistic estimate being 12-15. Overall official government estimates for 1985 appear to be at least 25 percent too high. (These figures are based on my own ongoing research on the international nuclear energy industry. See Joskow.)
- 45 Nuclear Industry, March 1972, p. 12.
- 46 Nuclear Industry, February 1975, p. 5.
- 47 Nuclear Industry, July 1975, p. 4.
- 48 See Atomic Energy Commission, WASH 1139 (72) and 1139 (74), and Statistical Data of the Uranium Industry, January 1, 1972, p. 51.
- 49 See Nucleonics Week, Special Report, "Fuel Reprocessing and Storage", 1976.
- 50 See also Joskow and Baughman.
- 51 Nuclear Industry, June 1972, pp. 36-37; and AEC-WASH-1196, p. 15, April 1974; and Deutsches Atomforum, Natural Uranium Supply, pp. 184-185.
- 52 See Table 3.
- 53 Statement of Dean A. McGee in Hearings before the Joint Committee of Atomic Energy, February 5 and 6, 1974, p. 195.
- 54 Federal Energy Administration, National Energy Outlook, February 1976, p. 258.
- 55 Nucleonics Week, September 4, 1975.



56 See Kidder, Peabody Report, p. 21.

57 U.S. Energy Research and Development Administration, Statistical Data of the Uranium Industry, January 1, 1976, p. 64.

58 Series on hourly earnings in the mining industry, U.S. Bureau of Labor Statistics, Handbook of Labor Statistics, 1975, p. 48.

59 See USAEC-WASH 1174-74, The Nuclear Industry 1974, p. 39; and National Academy of Sciences, p. 12.

60 See Deutsches Atomforum, Natural Uranium Supply, 1975, p. 208; and Nuclear Industry, June 1972, p. 36.

61 See, for example, OECD Nuclear Energy Agency and International Atomic Energy Agency Joint Report, Uranium, August 1973, p. 11.

62 See Footnote 59 above, National Academy of Sciences, p. 12.

63 National Academy of Sciences, p. 12.

64

Concentration Levels in U.S. Coal Production

Percentage of Coal Production

	<u>1972</u>
four firms	30.4
eight firms	40.5
twenty firms	55.1

Source: Competition in the U.S. Energy Industry,  
Duchesneau, p. 76.

65

Concentration Level in Midwestern Coal Production

Percentage tons of coal produced

	<u>1960</u>	<u>1962</u>
four firms	52.3	54.6
eight firms	69.7	74.2
twenty firms	89.2	N/A

Source: Duchesneau, p. 78.

66

1972 Concentration Ratios for Industries Often Thought  
to be Characterized by Oligopolistic Pricing Behavior

<u>Industry</u>	<u>Four Firm</u>	<u>Eight Firm</u>	<u>Twenty Firm</u>
Cigarettes	84	N/A	100
Primary Aluminum	79	92	100
Primary Copper	72	N/A	100
Metal Cans	66	79	92
Turbines & Turbine generator sets	90	96	99
Transformers	59	75	90
Motor Vehicles	93	99	99+

Source: 1972 Census of Manufacturers.

67 U.S. Bureau of Mines, 1952 Minerals Yearbook, vol. I, pp. 1086-1087; 1953 Minerals Yearbook, vol. I, P. 1207; 1954 Minerals Yearbook, vol. I, pp. 1244 and 1249.

68 U.S. Bureau of Mines, 1957 Minerals Yearbook, vol. I, p. 1224.

69 Ibid., p. 1222.

70 In 1963 there were 730 mines and 24 mills operating. By 1968 the industry was reduced to 320 mines and 13 mills in operation. U.S. Bureau of Mines, 1963 Minerals Yearbook, vol. I, pp. 1171-1172; and 1968 Minerals Yearbook, vol. I, p. 1118.

71 See U.S. ERDA, Statistical Data of the Uranium Industry, GJO-100-75, p. 25.

72 U.S. AEC, Statistical Data of the Uranium Industry, January 1969, p. 41.

73 Nuclear Industry, December 1969, pp. 16-17; Nucleonics Week, March 6, 1969, and October 21, 1971.

74 Deutsches Atomforum, op. cit., p. 186-187.

75 Nucleonics Week, November 2, 1972, p. 6; Nuclear Industry, February 1973, p. 48.

76 Deutsches Atomforum, op. cit., pp. 184-187.

- 77 NUEXCO Report, no. 48, July 19, 1972, p. 1; USAEC-WASH 1174.
- 78 Minerals Yearbook and AEC Annual Reports.
- 79 The Wall Street Transcript, March 27, 1972, p. 27, 773; and USAEC-WASH 1242, May 1973, p. 5.
- 80 Nuclear Industry, June 1969, p. 46.
- 81 Nuclear Industry, March 1974, pp. 8-9.
- 82 Deutsches Atomforum, op. cit., pp. 184-187.
- 83 Hearings before the Joint Committee on Atomic Energy, 93rd Congress, 1st Session, July 31 and August 1, 1973, p. 96.
- 84 NUEXCO, Report No. 64, November 26, 1973.
- 85 Joint Committee on Atomic Energy, Hearings, 93rd Congress, 2nd Session, September 17 and 18, 1974, p. 78 and p.
- 86 NUEXCO, Report No. 55, February 21, 1973.
- 87 Joint Committee on Atomic Energy, Hearings, 93rd Congress, 1st Session, March 7, 8, 26, and April 17, 1973, pp. 88.
- 88 Nuclear Industry, January 1973, p. 14.
- 89 NUEXCO, Report No. 59, June 20, 1973; and NUEXCO, Report No. 60, July 20, 1973.
- 90 NUEXCO, Report No. 61, August 20, 1973; NUEXCO, Report No. 62, September 20, 1973; and Nuclear Industry, December 1973, p. 20.
- 91 Kidder, Peabody Report, p. 5.
- 92 NUEXCO, "Uranium Prices vs. Costs: A Topical Report", January 30, 1976.
- 93 See Solow, p. 6.
- 94 See Table 3.

- 95 Kidder, Peabody Report, p. 5.
- 96 Kidder, Peabody Report, p. 6.
- 97 Ibid., pp. 9-11
- 98 Ibid., p. 8.
- 99 Ibid., p. 7.
- 100 Based on an examination of announced dates of reactor orders and fuel supply contracts.
- 101 I have been able to find announcements of purchases of 15,000 tons of uranium prior to 1973. A contract for 6,670 tons with a South African firm was also almost certainly prior to 1973. I was unable to find purchase dates for the remaining contracts.
- 102 Kidder, Peabody Report, pp. 31-32.
- 103 Joskow and Baughman, p. 19.
- 104 Submission of Walter T. Schultheis before the Connecticut Public Utilities Control Authority, Docket No. 751206, 1975.
- 105 See Business Week, December 22, 1975, pp. 15-16.
- 106 See Opinion in Eastern Air Lines, Inc. vs. Gulf Oil Corporation, U.S. District Court, Southern District of Florida, October 20, 1975.
- 107 See Footnotes 73, 75, 79, 85; and Nucleonics Week, June 28, 1973, p. 3.
- 108 See pp. 9-10 above.
- 109 See pp. 10-11 above.
- 110 See Posner, p. 42.



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