Chapter 8

The Nuclear Renaissance, Sensitive Nuclear Assistance, and Nuclear Weapons Proliferation

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Many analysts argue that the nuclear renaissance could lead to the international spread of nuclear weapons.[i] While there are considerable distinctions among the arguments made by these authors, the essential logic linking the nuclear renaissance to nuclear weapons proliferation is fairly straightforward.[ii] If the international demand for nuclear energy remains high, countries with nuclear energy programs will need access to nuclear fuel (Gourley and Stulberg this issue). While countries can receive nuclear fuel-cycle services from other states, those with strong interests in nuclear energy may prefer to produce nuclear fuel domestically in order to insulate themselves from the vagaries of strategic bargaining and the international market (Stulberg this issue). Most of the countries interested in producing nuclear fuel domestically will not be able to develop these sophisticated nuclear technologies indigenously and will, therefore, need to acquire assistance from other more advanced nuclear suppliers. Because the existing nuclear suppliers have strong economic incentives to export sensitive nuclear materials and technology, these states should be able to secure international help (e.g., Potter 1982, Braun and Chyba 2004). Finally, after having acquired sensitive dual-use nuclear technologies -- such as uranium enrichment and plutonium reprocessing technologies that can be used to produce fuel for nuclear power plants, or nuclear weapons, or both -- many countries might eventually opt to build nuclear weapons arsenals (e.g., Sagan and Miller 2009, 13). In short, the nuclear renaissance could lead to nuclear proliferation.

In this chapter, I argue that the argument about a link between the nuclear renaissance and widespread nuclear weapons proliferation is misguided. While many countries might want sensitive nuclear fuel-cycle capabilities, few will be able to acquire them. Nuclear suppliers are unwilling to transfer sensitive nuclear technologies to any country willing to pay the price.

Rather, they are most likely to provide sensitive nuclear assistance under relatively rare strategic conditions (Kroenig 2009a, 2010). While a small number of countries might receive sensitive nuclear help, the vast majority of states will be unlikely to secure an international supplier. Without access to nuclear fuel-cycle facilities, countries -- even those that badly want to join the nuclear club -- will not be able to build nuclear weapons.

Although this chapter argues that the nuclear renaissance is unlikely to result in a proliferation cascade, this chapter in no way seeks to minimize the threat of nuclear proliferation. The spread of nuclear weapons remains one of the greatest threats to U.S. national security. At the time of writing in 2012, Iran's nuclear program continued to advance and U.S. government officials speculated that nuclear weapons in Iran could have grave consequences for U.S. national security, including: enhancing Iranian hegemonic ambitions; providing a cover under which Tehran can step up support for proxy groups or to engage in more aggressive coercive diplomacy; encouraging other states in the Middle East to go nuclear and weakening the global nonproliferation regime; and, most worryingly, triggering possible nuclear war between Iran and Israel, or Iran and the United States. Even a single instance of nuclear proliferation, therefore, provides a significant cause of concern. It is indeed possible that over the course of the coming decades a renaissance in nuclear energy could result in a small number of additional countries joining the nuclear club. This chapter, therefore, does not imply that we should not be worried about these cases. Rather, the argument here is that, even in the midst of a global nuclear renaissance, the forces that moderate the behavior of the nuclear suppliers will provide a check against the widespread diffusion of nuclear weapons.

The rest of the chapter elaborates on this argument in five parts. First, I review the logic linking the nuclear renaissance to the diffusion of sensitive fuel-cycle technologies and

eventually to nuclear weapons proliferation. Next, I review the evidence supporting the argument that strategic conditions heavily condition the transfer of sensitive nuclear materials and technology. Third, I apply these findings to the question of whether the nuclear renaissance will result in nuclear proliferation. Finally, I conclude with a recap of the argument and discuss the implications for policymakers interested in stemming the spread of nuclear weapons.

The Nuclear Renaissance and Nuclear Proliferation

The idea that the nuclear renaissance will result in widespread nuclear weapons proliferation rests on four propositions. This section adumbrates each of these propositions in turn.

1. The nuclear renaissance will result in an increased demand for nuclear fuel. If the nuclear renaissance comes to fruition and many more countries around the world possess nuclear power programs, and the existing countries with nuclear energy programs increase their share of domestic energy provided by nuclear power, then there will be an increased demand for nuclear fuel. The logic is simple: more countries operating more nuclear power reactors will result in a greater need for nuclear fuel.

The production of nuclear fuel requires a series of technically sophisticated steps. Enriched-uranium fuel is the result of a process that begins by mining natural uranium, milling the natural uranium into a dry powder known as "yellowcake," converting the powder into uranium hexafluoride gas, enriching the uranium -- separating the nonfissionable U-238 isotopes of uranium from the fissionable U-235 isotopes -- then finally fabricating the enriched uranium into solid metal pellets that are packed into metal nuclear fuel rods.

Plutonium can also be used as a nuclear fuel. PU-239 is a byproduct of a nuclear reaction. Spent fuel rods, therefore, that have passed through a nuclear reactor contain some plutonium. The plutonium can be separated from the other elements of the spent fuel using a chemical process and then converted into plutonium fuel rods.

In order to acquire nuclear fuel made from either uranium or plutonium, countries have two broad options. They can operate nuclear fuel-cycle facilities domestically -- either uranium enrichment, or plutonium reprocessing, or both -- and produce their own nuclear fuel. Alternatively, if they lack domestic fuel-cycle capabilities, they can have another country or international body provide them with fuel services. Nuclear fuel providers, such as France and Russia, ship recipient countries nuclear fuel for use in nuclear power reactors and then reclaim the spent fuel for reprocessing or storage. By contracting for nuclear fuel services, countries can enjoy the benefits of a nuclear power program without developing, maintaining, and operating their own domestic fuel-cycle capabilities. There are costs, however, to being dependent on the international market for nuclear fuel.

2. Countries will prefer to possess the ability to produce nuclear fuel indigenously, rather than be vulnerable to international fuel supplies. Many analysts argue that countries will tend to prefer to produce fuel indigenously for two reasons. First, countries would like to produce nuclear fuel themselves for reasons of energy security (Stulberg this volume). Relying on international suppliers to meet their core energy needs leaves countries vulnerable. A halt in the shipment of much-needed nuclear fuel due to changing economic and political incentives in the nuclear suppliers could cripple a country's economy. As Stulberg points out, policymakers and analysts recognize this problem and are attempting to devise means to guarantee countries access

to international nuclear fuel supplies through international nuclear fuel banks and fuel assurances. As Stulberg also notes, however, there are inherent challenges to making these promises credible. Indeed, on a few occasions in the past, countries have had their nuclear fuel supplies threatened and many aspiring nuclear nations are skeptical that promises of international nuclear aid will be consistently kept.

Second, some countries might seek to develop a domestic fuel-cycle capability as a security strategy to hedge against an uncertain future. Nuclear fuel-cycle facilities can be used to produce nuclear fuel for reactors or for nuclear weapons. Countries may seek to acquire capabilities under the guise of a nuclear energy program in the near future in order to develop and maintain the ability to dash to a nuclear weapons program down the road (McFarlane this volume). In short, many analysts believe that future nuclear power countries will prefer to produce fuel domestically for reasons of energy security, and/or to keep the nuclear weapons option open.

3. Countries will be able to acquire sensitive nuclear fuel-cycle technologies with relative ease in the international nuclear marketplace. Wanting nuclear capabilities and having them are separate matters, of course (Gartzke and Kroenig 2009). The vast majority of countries that might want nuclear fuel-cycle facilities will not be able to produce them indigenously. Indeed, the countries that currently express interest in developing a nuclear energy infrastructure, such as Jordan, Vietnam, and Kazakhstan, among many others, possess low-levels of technical and industrial capacity. If these countries are to develop a nuclear fuel-cycle capability, they will require international assistance.

Many analysts (e.g., Potter 1982, Jones 2007) suggest that international nuclear assistance can be readily secured. They claim that nuclear supplier states can earn handsome profits by exporting uranium enrichment and plutonium reprocessing technologies to the highest bidder. Pundits (e.g., Chestnut 2007) have argued that North Korea's economy, for example, is in such poor shape that Pyongyang would be willing to export anything, including sensitive nuclear technology, in order to earn hard currency. Others (e.g., Braun and Chyba 2004) argue that even if state suppliers are unwilling to provide sensitive nuclear assistance, non-state proliferation "rings," exemplified by the former A.Q. Khan network in Pakistan, are more than willing to transfer sensitive nuclear technologies. According to this line of thought, the nuclear renaissance will lead to a significant increase in the number of countries with a fully-developed nuclear-fuel cycle.

4. Countries that receive sensitive nuclear assistance will be able to produce nuclear weapons. The international spread of nuclear facilities could lead to many potential security challenges, including concerns about nuclear safety, sabotage of nuclear facilities, terrorist theft of nuclear materials, nuclear weapons proliferation, and destruction of nuclear facilities in a conventional war (Miller and Sagan 2010, 126). This chapter focuses on nuclear weapons proliferation.

As more countries acquire sensitive fuel-cycle facilities, more countries will have the ability to produce nuclear weapons. The most difficult part of building a nuclear weapon is producing the weapons-grade fissile material (either highly-enriched uranium, or separated plutonium) that forms the core of the nuclear device. Sensitive nuclear technologies, uranium-enrichment and plutonium reprocessing technologies in particular, are dual-use technologies that

can be used to produce nuclear fuel for use either in nuclear power reactors or nuclear weapons. In fact, once countries have mastered the ability to produce nuclear fuel, some analysts argue that they are no more than a few screw-driver turns away from possessing nuclear weapons. As Mohamed El-Baradei (2003), the Director General of the IAEA averred, "should a state with a fully-developed fuel-cycle capability decide, for whatever reason, to break away from its non-proliferation commitments, most experts believe it could produce a nuclear weapon within a matter of months." Similarly, Scott Sagan and Steven Miller (2009, 13) write, "Indeed, the connection between power and weapons is somewhat inevitable because key technologies in the nuclear sector--notably, uranium enrichment and plutonium reprocessing capabilities--are relevant to both."

Countries that possess fuel-cycle technologies, therefore, exist in a state of "nuclear latency" (Sagan 2010). In other words, they have the ability to produce nuclear weapons in short order if they chose to do so. While many countries might remain latent nuclear powers for an extended period of time, the spread of sensitive nuclear technologies greatly increases the risk that additional countries will eventually engage in overt nuclear proliferation. Again, according to Sagan and Miller (2009, 13), depending on which "capabilities spread to which states, especially regarding uranium enrichment and plutonium reprocessing, a world of widely spread nuclear technologies could be…a world where more states possess nuclear weapons." Indeed, as I have shown in previous research, states that receive sensitive nuclear assistance from more advanced nuclear suppliers are five and a half times more likely to acquire nuclear weapons than similar states that do not get outside help (Kroenig 2010, 171).

This chapter focuses on sensitive nuclear technologies because there is a widespread scientific and policy consensus that there is a direct link between the possession of sensitive,

fuel-cycle technologies and the ability to produce nuclear weapons. On the other hand, other less sensitive types of nuclear technology, such as light-water nuclear power reactors, are more proliferation resistant. Matthew Fuhrmann (2009) proposes that all nuclear transfers, regardless of their level of sensitivity, contribute to proliferation, but these claims are based on an analysis of nuclear cooperation agreements (many of which are subsequently canceled), not on actual nuclear transfers. Using data on transfers of nuclear technology that have actually occurred, I show instead that there is not a statistical link between the receipt of civilian nuclear assistance and the probability that a country subsequently goes nuclear (Kroenig 2010, 159-169). The reason is simple: while some recipients of civilian nuclear assistance, such as India, went on to build the bomb, many more, including Australia, Belgium, Egypt, Finland, Peru, Vietnam, and others, have not.[iii] A consideration of less sensitive nuclear technologies and the nuclear renaissance can be found elsewhere in this volume (Fuhrmann, this volume).

In sum, the four propositions above combine to suggest that the nuclear renaissance will lead to a significant increase in the number of countries with a fully-developed nuclear-fuel cycle and, in turn, to the proliferation of nuclear weapons.[iv] The underlying logic of this argument is sound, but not all of the key propositions on which the argument rests stand up to empirical scrutiny. In a previous chapter, Stulberg questioned whether countries will prefer to produce nuclear fuel domestically and identified conditions under which the international community can provide credible fuel assurances that are likely to convince future nuclear power states to accept international fuel-supply arrangements. Alexander Montgomery (this volume) challenges the evidence underlying the belief that sensitive nuclear assistance causes nuclear proliferation. The remainder of this chapter, in contrast, will present evidence that undermines proposition three. Countries interested in developing a domestic nuclear fuel cycle capability will struggle to find

an international supplier. Sensitive nuclear materials and technologies are not freely available on the international nuclear marketplace. Nuclear suppliers are quite selective in the provision of sensitive nuclear assistance and this greatly complicates state efforts to acquire sensitive nuclear technology. As we will see in the next section, states are most likely to provide sensitive nuclear assistance and technology only under relatively rare strategic conditions.

The Strategic Logic of Nuclear Assistance

In *Exporting the Bomb: Technology Transfer and the Spread of Nuclear Weapons,* I present the results of the first systematic analysis of why countries export sensitive nuclear materials and technology (Kroenig 2010). In this section I highlight four findings that are particularly relevant to our assessments of whether the nuclear renaissance will result in a cascade of nuclear weapons proliferation.

First, I found that the state-sponsored transfer of sensitive nuclear materials and technology is extremely rare. Since 1945 there have been only fourteen instances in which capable nuclear suppliers have transferred sensitive nuclear materials and technology to nonnuclear weapon states. I identify twenty countries that could provide sensitive nuclear materials and technology and nearly two hundred potential recipient countries. Yet, despite the tens of thousands of potential situations in which nuclear transfers could have occurred, there have been slightly more than a dozen instances of sensitive nuclear transfer.

Second, the sub-state smuggling of significant quantities of sensitive nuclear materials and technologies is also extremely rare. Pundits (e.g., Braun and Chyba 2004) warn of future "proliferation rings," in which rogue scientists and private enterprises transfer the means of producing nuclear weapons without the authorization or even knowledge of national

governments. But, as underscored by other chapters in this volume, such predictions are overblown owing to logistical problems confronted by illicit trafficking networks (Hastings) and the challenges of absorbing tacit nuclear weapons-related knowledge (Montgomery). Moreover, since 1945, there has only been one instance in which a significant transfer of sensitive nuclear materials or technology occurred without government knowledge.[v] There have been many failed attempts and a few actual transfers of small quantities of fissile materials from secure nuclear facilities across national borders, but these small-scale transfers are relatively insignificant and do not suggest that the large-scale transfer of sensitive nuclear materials and technology are likely.[vi]

Arguments about future "proliferation rings" are generally extrapolations from the experience of the A.Q. Khan-led nuclear transfers from Pakistan to Iran, Libya, and North Korea from 1987 to 2002. Analysts cite this case as an example of how a "rogue scientist" acting without the authorization of a national government could transfer nuclear materials and technologies to other countries. As I show in *Exporting the Bomb*, however, the 'A.Q. Khan' transfers, especially during the early phases, were the project of the Pakistani state (Kroenig 2010). A.Q. Khan's proliferation ring could not have developed without the support of, and its early incarnation indeed was an official policy of, the Pakistani government. Moreover, as discussed in the chapter by Hastings, once the network was deprived of access to state prerogatives, both the structure and vulnerability changed. Thus, if the 'A.Q. Khan' case is a harbinger of things to come, it suggests that we should be most concerned about state decisions to export sensitive nuclear material and technology, not sub-state "proliferation rings."

Third, as I demonstrate in my book and contrary to conventional wisdom, there is no systematic relationship between economic factors and patterns of sensitive nuclear assistance. I

demonstrate that states like North Korea, that are economically underdeveloped, or that are suffering through periods of poor economic performance, are neither more nor less likely to export sensitive nuclear materials. In addition, I show that economic considerations are often far from the minds of state leaders who decide to provide sensitive nuclear assistance. This makes sense given that sensitive nuclear assistance does not generally result in large economic gains for the supplier. This is not to say that economic considerations are irrelevant. States do sometimes seek economic payment in exchange for sensitive nuclear transfers, but they are only likely to do so when such transfers are consistent with an underlying strategic logic.

Fourth, I show that strategy, not economics, largely determines countries' willingness to export sensitive nuclear materials and technology. Nuclear suppliers are most likely to provide sensitive nuclear assistance when doing so would threaten an enemy, but not threaten themselves. When is a country most threatened by nuclear proliferation? I argue that the spread of nuclear weapons threatens powerful states more than it threatens weak states. This is because nuclear weapons proliferation constrains the military freedom of action of powerful states. Powerful states can threaten or promise to protect other states. But when other states acquire nuclear weapons, these threats to do harm, or promises to provide protection, lose their credibility. This fact leads to three strategic conditions under which states are most likely to provide sensitive nuclear assistance. First, the less powerful a state is relative to a potential nuclear recipient, the more likely it is to provide sensitive nuclear assistance to that state. The logic is simple. States avoid constraining their own military freedom of action. Second, states are most likely to provide sensitive nuclear assistance to states with which they share a common enemy. By providing nuclear assistance to these states, they can impose strategic constraints on other, more powerful rivals. Third, states that depend on superpower protection to provide for

their own security are unlikely to provide sensitive nuclear assistance. These states judge that the costs of antagonizing a superpower patron outweigh any benefits of participating in sensitive nuclear transactions.

The strategic conditions that facilitate sensitive nuclear transfers can be illustrated by the case of Chinese nuclear assistance to Pakistan (Kroenig 2010, 112-120). From 1981 to 1986, China helped Pakistan construct and operate uranium enrichment facilities, transferred enough highly enriched uranium for two nuclear weapons, and shared a nuclear bomb design. Due to geographic constraints and a lack of airlift and amphibious invasion capabilities, China lacked the ability to project power over Pakistan, meaning that its own military freedom of action would not be constrained if Pakistan acquired the bomb. In addition, by providing nuclear assistance to Pakistan, China could impose strategic costs on its longtime regional rival, India, a country that had the ability to project power against Pakistan. Finally, as a nuclear weapon state, China enjoyed a measure of security independence and did not need to worry that sensitive nuclear exports would hurt its relationship with a superpower security provider.

In this volume, Gartkze suggests additional motives for sensitive nuclear transfers. He claims that states will be more willing to provide sensitive nuclear assistance to states that are likely to acquire nuclear weapons anyway, regardless of whether they get help. In this way, the supplier can garner some influence over the recipient without significantly contributing to proliferation. In addition, Gartzke suggests that nonnuclear weapon states with advanced nuclear technology will be more likely than nuclear weapon states to provide sensitive nuclear assistance, because nuclear weapon states have an incentive to limit the size of the nuclear club. His conjectures are plausible, but the empirical record demonstrates that they are incorrect. A careful look at the most important cases of sensitive nuclear assistance does not turn up a single

instance of a policymaker choosing to provide nuclear assistance because he or she believed the recipient was bound to proliferate anyway. In fact, leaders often provide nuclear assistance because they believe that the recipient would not be able to proliferate without their help. As Guy Mollet, the Prime Minister behind France's nuclear assistance to Israel explained, "When my government came to power, Israel asked for French assistance; I did my duty as a democrat and a Frenchman by supplying this endangered country with the arms it needed to survive" (as quoted in Troen and Shemesh 1990, 131). Indeed, while some things may seem pre-ordained in hindsight, there was nothing inevitable about China, Israel, Pakistan, or North Korea joining the nuclear club. In fact, without external help it is quite possible that some of these countries would not possess nuclear weapons today. Moreover, Gartzke's explanation raises the question as to why a supplier should reasonably expect that the provision of unneeded help should buy any influence. Finally, contrary to Gartzke's other claim, I have systematically demonstrated that nuclear weapon states are more, not less, likely to provide nuclear assistance than are capable nonnuclear weapon states (Kroenig 2010, 5, 178). This is because nuclear-armed states enjoy a degree of security independence and need to worry less about incurring the wrath of the international community.

Sensitive Nuclear Assistance and the Nuclear Renaissance

The above analysis of historical patterns of sensitive nuclear assistance has important implications for our current attempts to understand the nuclear renaissance. Of course, one should be cautious about blindly extrapolating historical trends into the future. It is always possible that a radical discontinuity could emerge, creating a future that will be utterly unrecognizable from our current temporal perch. As the Danish physicist Neils Bohr is reported

to have said, "Prediction is very difficult, especially about the future." Nevertheless, past is often prologue and much of social science is based on the idea that historical data can help us better understand the workings of enduring social phenomena. In addition to conjectures by informed analysts therefore, the findings of careful social science research can provide a valuable tool in helping us to forecast the possible proliferation consequences of the nuclear renaissance.

This research demonstrates that the idea that so-called "proliferation rings" are an important driving force for future nuclear proliferation exists more in the imagination of analysts than in reality. The sub-state smuggling of significant quantities of sensitive nuclear materials and technology has been virtually nonexistent in the past. It is unlikely, therefore, that countries will be able to produce functioning nuclear fuel-cycle facilities with help from non-state actors. Some may object that while sub-state proliferation rings leading to significant nuclear transfers have been rare historically, they could become more common in the future due to globalization, the diffusion of nuclear know-how, and worldwide reductions in technological barriers to entry in the nuclear field. There are, however, reasons to be skeptical of this claim. Governments have strong political, economic, and strategic incentives to maintain tight control over their most sensitive nuclear technologies. This has been true in the past and it will likely remain so in the future. Granted, some key component parts for the uranium enrichment facilities exported by A.Q. Khan's Pakistan were produced by private firms in Malaysia, Switzerland, and South Africa. But these actors could not have been important nodes in a global nonproliferation network had it not been for strong state support on both the recipient and *supplier* side of the transactions. As was pointed out above, A.Q. Khan's nuclear supply network was supported by the Pakistani state through and through. And the recipients, Iran, Libya, and North Korea, were eager to receive sensitive nuclear help. Experience suggests, therefore, that we should be much

more concerned about the *state-sponsored* transfer of sensitive nuclear materials and technology, not sub-state "proliferation rings."

We also saw above, however, that state-sponsored transfer of sensitive nuclear materials and technology also has been exceedingly rare. It is unlikely, therefore, that any particular new nuclear power state will receive sensitive nuclear assistance from other states. Since 1945, there have only been fourteen instances of sensitive nuclear assistance. Moreover, some of these transfers were to the same recipient state. Since 1945, only twelve countries have been fortunate enough to receive sensitive nuclear assistance from a more advanced nuclear supplier state. Many others have tried to obtain such assistance and failed. For example, while exploring the nuclear option in the 1960s, Egypt requested sensitive nuclear assistance from France, the Soviet Union, and China, only to be rebuffed each time. There is good reason to believe, therefore, that countries seeking sensitive nuclear assistance today will also encounter great difficulties.

While future sensitive nuclear transfers are unlikely, the above analysis suggests the conditions under which they will be most likely to occur. Despite a conventional wisdom to the contrary, states do not provide sensitive nuclear assistance for economic reasons. Capable nuclear suppliers experiencing economic underdevelopment or slow or negative growth rates are not more likely to export sensitive nuclear materials and technology than their wealthier counterparts. One would be ill advised, therefore, to make predictions about the future of the nuclear renaissance by identifying relationships between economically desperate nuclear suppliers, like North Korea, and deep-pocketed aspirants, such as Saudi Arabia.

Rather, sensitive nuclear transfers are driven by a strategic logic. If we seek to identify whether the nuclear renaissance will lead to nuclear weapons proliferation and which countries will be most likely to acquire nuclear weapons in a future nuclear renaissance, we must focus on

these strategic conditions. The nuclear supplier-nuclear recipient dyads that could engage in sensitive nuclear cooperation are those in which: the former lacks the ability to project military power over the latter, the states possess a common enemy, and neither state depends on the United States to provide for its core security needs.

Focusing on the last condition first, it is evident that many capable nuclear suppliers are protected by the U.S. security umbrella and will therefore be unlikely to provide sensitive nuclear assistance. These countries will prefer to avoid jeopardizing an important security relationship by antagonizing Washington on this important political issue. Table 8-1 lists the twenty states capable of providing sensitive nuclear assistance in the world today. Looking at the table, we can see that over half of the countries (12 of 20) share a close military relationship with the United States. The remaining countries, therefore, are the nuclear suppliers of special concern. In other words, there are only eight countries in the world today that are at a heightened risk of providing sensitive nuclear assistance.

-Insert Table 8-1 here-

Moreover, there are additional strategic factors that will shape how these countries view the attractiveness of nuclear exports. Returning to the first strategic condition shaping nuclear assistance, we can infer that these eight nuclear suppliers will be unlikely to provide sensitive nuclear assistance to countries against which they can project military power; they will prefer to avoid constraining their own military freedom of action. This consideration limits the pool of potential nuclear suppliers for would-be proliferators even further. China, for example, will be unlikely to provide sensitive nuclear assistance to other states in Asia because it will desire to

maintain its military predominance in this region. Similarly, Iran will be reluctant to export sensitive nuclear materials to other actors in the Middle East. Any country seeking to acquire sensitive nuclear materials and technology, therefore, will generally be forced to search for one of a handful of capable nuclear suppliers beyond its own geographic region.

Finally, we turn to the second condition. Taking this condition seriously suggests that future sensitive nuclear transfers will most likely occur between nuclear suppliers and nuclear recipients that share a common enemy. In these situations, nuclear suppliers could provide nuclear assistance in order to constrain a powerful rival. Considering the remaining pool of supplier states, we can identify only a small number of supplier-recipient dyads that meet this criterion. Some of the remaining nuclear suppliers, for example, have a history of antagonism and political-military competition with the United States. Countries such as Russia, China, Iran, and North Korea could conceivably provide sensitive nuclear assistance to states that are hostile to Washington in an effort to constrain U.S. military power. Potential recipients that fit this description could include Bolivia, Burma, Syria, or Venezuela.

North Korea has already begun to provide nuclear assistance to some of these recipient states. From 2001 to 2007, for example, North Korea helped Syria construct a plutonium-producing reactor, before Israel destroyed the facility in a preventative military attack in September 2007. As far as we know, North Korea did not export fuel cycle technologies to Syria, but the nuclear reactor may have been the first step in what was intended to be a broader nuclear relationship. Also, according to recent reports (e.g., Border 2009), North Korea may also be providing nuclear assistance to Burma. True to the pattern of sensitive nuclear transfers identified above, North Korea's nuclear exports may be driven in part by a desire to constrain American power. In a recent interview with a Japanese journalist, a high-ranking North Korean

official explained the strategic goals behind North Korea's transfers. He claimed that: "If we spread our nuclear weapons to other countries…the power of the U.S. would be relatively decreased" (Abe 2009). He continued to argue that nuclear proliferation to other countries improves North Korea's relative standing because: "Once the U.S. is not able to be predominant over others, then we can be on equal footing." Given the continued animosity between Washington and Pyongyang there is little reason to believe that North Korea's nuclear generosity to America's rivals will end anytime soon. Indeed, the North Korean official threatened that Pyongyang will continue "to sell our nuclear arms to countries which hate the U.S."

India is also a country at risk of exporting sensitive nuclear materials and technology. Given its historical rivalry with China, India could conceivably provide sensitive nuclear assistance to small sates on China's border in order to constrain Beijing's military freedom of action. Illustrating this type of thinking, Bahrat Karnad, a Professor of National Security Studies at the Centre for Policy Research in India, argued that New Delhi should provide sensitive nuclear assistance to Vietnam and Taiwan. In a recent book, Karnad (2002) writes, "India should, likewise, create precisely the kind of dilemmas for China that Beijing has created for it with respect to a nuclear weapons and missile-equipped Pakistan by arming Vietnam with strategic weapons" and by "cooperating with Taiwan in the nuclear and missile fields." While Karnad's views do not represent the official policy of the Indian government, they demonstrate that the factors that have motivated sensitive nuclear assistance in the past also could fuel them under special conditions in future cases.

In sum, given our understanding of why states have provided sensitive nuclear assistance, there is good reason to believe that the international transfer of sensitive nuclear materials and technology will remain uncommon. There are only a handful of nuclear supplier-nuclear

recipient dyads for which the conditions that encourage sensitive nuclear transfers are currently in place. Over the next couple of decades, therefore, it is reasonable to expect that there might be a few -- but only a few -- instances in which capable nuclear suppliers might provide sensitive nuclear assistances to nonnuclear weapon states. In other words, this analysis strongly suggests that predictions that the nuclear renaissance will lead to the widespread diffusion of sensitive nuclear materials and technology that in turn results in a cascade of nuclear weapons proliferation are likely exaggerated.

Conclusion

This chapter examined whether the nuclear renaissance will result in the international spread of nuclear weapons. I claimed that the idea that the nuclear renaissance will fuel future nuclear proliferation rests on four propositions: that the nuclear renaissance will lead to an increased demand for nuclear fuel; that countries will prefer to possess domestic nuclear fuel-cycle facilities, rather than receive international fuel services; that countries will be able to acquire sensitive nuclear assistance from other states; and that once countries receive sensitive nuclear assistance, they will be more likely to produce nuclear weapons.

In contrast, I argued that the nuclear renaissance is unlikely to result in nuclear weapons proliferation because the third of these four propositions is not true. Acquiring sensitive nuclear assistance and technology is quite difficult. Drawing on my own previous analysis of the causes of sensitive nuclear assistance, I demonstrated that the international transfer of sensitive nuclear materials and technology is uncommon and is most likely to occur only under relatively rare strategic conditions. For this reason, countries -- even countries that badly want to build

domestic fuel-cycle facilities -- will struggle to identify a willing foreign supplier. And, without international aid, countries will be less able to produce nuclear weapons.

When combined with the other chapters in this volume, the findings of this analysis give us further reason to doubt the conventional wisdom about a direct renaissance-proliferation link. Four assumptions underlie this proposition, but the chapters of this volume suggest that at least three of these four assumptions are problematic. Stulberg (this volume) argues that it might be possible to design a system that provides a credible commitment to recipients of nuclear fuel cycle services. If Stulberg is correct, many future nuclear power states will be willing to accept international fuel supplies and will forgo the construction of domestic fuel-cycle facilities. I demonstrated that the countries that do decide to build domestic fuel-cycle facilities will be unlikely to succeed because they will struggle to secure international help. And finally, Montgomery (this volume) claims that even if countries receive sensitive nuclear assistance, they will be unable to construct nuclear weapons because, for a variety of reasons, international nuclear aid might actually impede a country's nuclear development. I have good reason to be skeptical of these claims. In previous research (Kroenig 2009b, 2010), I have systematically demonstrated that countries that receive sensitive nuclear assistance are more likely to acquire nuclear weapons. Nevertheless, Montgomery's chapter makes some thought-provoking claims that give us reason to suspect that sensitive nuclear assistance might provide a bigger boost to nuclear programs in certain types of recipient states than in others.

In March 2011, an earthquake and tsunami triggered a nuclear meltdown at the Fukushima-Daiichi nuclear power plant in Japan. This unexpected disaster might influence the development of the nuclear renaissance, as other authors in this volume point out, but it does not greatly affect our expectations about future patterns of sensitive nuclear transfers. Nuclear

reactors produce sustained nuclear chain reactions that can generate tremendous power, but they can also result in devastating accidents. For this reason, nuclear reactors have been the incubators of history's worst nuclear disasters, including Fukushima. In addition, the spent fuel rods at Fukushima underwent a partial meltdown when the water levels in the spent fuel pools dropped. This has led to calls for more plutonium reprocessing which could reduce the density of spent fuel rods left cooling in pools and, in turn, the risk of meltdown. While the Fukushima nuclear accident, therefore, could dampen leaders' willingness to build nuclear reactors in their own countries and could increase the demand for reprocessing capabilities in countries currently operating reactors, my analysis of the causes of sensitive nuclear assistance gives us little reason to believe that these considerations will greatly affect the calculations of the potential suppliers to export fuel-cycle technologies.

This chapter not only drew lessons from past cases of nuclear assistance, but it also identified a small number of cases in which future nuclear transfers could occur. Of particular concern are the small number of capable nuclear suppliers that do not enjoy a close strategic relationship with the United States and that could conceivably benefit from additional constraints on American military power. China, Iran, Russia, and North Korea are at the top of the list of nuclear suppliers that might make such a strategic calculation. The respective leaderships might be tempted to export the bomb to some of Washington's enemies interested in developing nuclear programs, including Bolivia, Burma, Syria, or Venezuela. Intelligence analysts and policymakers must closely watch these countries for signs of fledgling nuclear relationships and adopt measures now to prevent sensitive transfers before they occur.

There are a number of steps that Washington can take to ward off future nuclear transfers. To begin, the development of nuclear fuel guarantees could help to satisfy demand for nuclear

fuel in new nuclear power states without generating a corresponding risk of nuclear proliferation. For this reason, the development of a credible international fuel services system is of paramount importance. Accordingly, Stulberg's recommendations (this volume) should be read with great attention.

Contrary to the belief of many, tightening national export controls is only a small part of the overall solution. While export controls are an important policy tool, their utility rests on the assumption that proliferation is a problem that results from firms or bureaucracies exporting dual-use items without the knowledge or authorization of the central government. But, my analysis suggests that this is rarely a problem. The most important historical cases of sensitive nuclear transfer -- those that have led to the proliferation of nuclear weapons -- were the result of strategic decisions by national governments to help another country acquire sensitive nuclear facilities. When central governments make such a strategic decision, they can simply choose to override their own export control systems. Tightening export controls will not help address this problem.

What is needed, therefore, is an effort to alter the cost/benefits calculus of states that might be tempted to make the strategic decision to export sensitive nuclear materials and technology. There are a number of carrots and sticks that might be useful for such a purpose. Among the carrots, the United States could seek to extend security guarantees to nuclear suppliers who are not yet under Washington's security umbrella. We have seen that countries that depend on the United States for their core security needs are less likely to export sensitive nuclear materials or technology. Therefore, Washington could, for example, encourage Serbia to join the North Atlantic Treaty Organization and could continue to expand and deepen its current

strategic partnership with Pakistan. If these countries come to rely on Washington's protection, they will be more likely to think twice before conducting future sensitive nuclear transfers.

In some cases, however, carrots will fail to entice and Washington will need to reach for sticks. In these cases the United States should turn to threats in order to deter the international transfer of sensitive nuclear materials and technology. A declaratory policy to hold responsible states that transfer sensitive nuclear material and technology, visibly strengthened nuclear forensics capabilities, and improved capabilities to interdict illicit nuclear shipments, should induce caution in potential nuclear suppliers. This portfolio of policies will help to ensure that, despite a widespread belief to the contrary, the nuclear renaissance will not allow many more countries to possess the world's most dangerous weapon.

Table 8-1: Capable Nuclear Suppliers

Capable Nuclear Suppliers	
Country	**Year**
Argentina*	1969
Belgium*	1966
Brazil*	1988
China	1964
France*	1958
Germany*	1969
India	1964
Iran	2009
Israel*	1966
Italy*	1970
Japan*	1977
Netherlands*	1971
North Korea	1993
Norway*	1961
Pakistan	1986
USSR/Russia	1949
South Africa	1977
United Kingdom*	1951
United States*	1945
Yugoslavia/Serbia	1966
* An asterisk denotes capable nuclear suppliers that share a formal military alliance with the United States. These countries are unlikely to provide sensitive nuclear assistance to nonnuclear weapon states. Although not joined in a formal alliance, Israel is included in the list due to its strong and enduring security relationship with Washington.	

[i] See, for example, Miller and Sagan 2009; Lauvergeon 2009; Goldschmidt 2008; Frank Barnaby 2009; Tagarinski 2009; Fuhrmann 2009; Nutall 2004; Schmidt 2006; Shea and Zentner 2008; Allison 2008.

[ii] This is my own best articulation of the causal chain between the renaissance and proliferation and does not necessarily represent the views of any or all of the authors cited in footnote 1.

[iii] For more on this debate, see Bluth et al. 2010.

[iv] On the dangers of nuclear proliferation, see Beardsley and Asal this volume; Horowitz this volume.

[v] While working in the Netherlands in the late 1970s, Pakistani scientist A.Q. Khan was able to smuggle designs and key component parts for uranium enrichment facilities from Holland to Pakistan without the knowledge or authorization of the Dutch government. This transfer was made possible by the combination of a recipient with strong nuclear weapons ambitions, with a competent and nationalistic nuclear scientist placed in the laboratories of a nuclear-capable foreign country, which was relatively new to the operation of sensitive nuclear facilities that did not yet have adequate security measures in place.

[vi] For a list of these cases of nuclear smuggling, see Government Accountability Office 2002.