Various System Methodologies to Analyze Theft and Smuggling of Nuclear Material Cases

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Abstract

The world has experienced theft and smuggling of nuclear materials after the collapse of the former Soviet Union. There is a growing concern over the potential of transnational criminal groups and terrorist organizations that may have access to the nuclear materials through theft or smuggling cases. Despite the increasing measures to safeguard nuclear materials in countries, there still happen theft and smuggling cases. There are few studies that analyze these cases using different methodologies. This study presents a set of various methodologies, which can be used to make analyses on theft and smuggling of nuclear materials. There are two sections in this study: the first section examines the supply and demand sides in nuclear theft and smuggling cases, and the second one focuses on the system methodologies.

Key words: smuggling of nuclear materials, system methodologies, terrorist organizations, Al-Qaeda, organized crime

Introduction

Dramatic changes have been witnessed in the trends of nuclear proliferation. While the basic concern was the vertical nuclear proliferation between the US and the Soviet Union during the cold war, the trend changed and rogue states such as Iraq, Iran, and North Korea have become core countries in terms of proliferation debates. The recent trend is that nuclear materials have proliferated and been uncontrollably spread by criminals in the world through ongoing theft and smuggling cases, which is regarded as the most threatening (Lee, 2006). According to Bunn, if a technically sophisticated terrorist group could acquire the needed nuclear materials, it might be able to make a nuclear bomb, which could destroy a modern city (Bunn, 2010).

International security until the terrorist attacks on September 11, 2001 did not fully acknowledge the severity of this type of proliferation and its possible devastating consequences (Zaitseva, 2002). The international community is currently encountering the legacy of a post-Soviet transition with unanticipated challenges (Shelley, 2006). Trafficking of nuclear materials that have surged after the collapse of the Soviet Union is a recurrent and pervasive threat. The increasing smuggling and theft cases have resulted in the loss of an unknown amount of nuclear materials in the world. There is no certain information concerning the whereabouts of these lost materials (Lee, 1999). This threat is becoming more serious because US-funded security measures aimed at post-Soviet nuclear facilities and border crossings are exposed to technological and conceptual limitations (Shelley, 2006).

In this respect, studies aimed at detecting the perpetrators of ongoing theft and smuggling cases are needed to make effective policies. Currently, the amount of nuclear materials stolen or smuggled is not known. Many countries that have nuclear potential tend to abstain from issuing and sharing these cases with the international community. Therefore, new methodologies that analyze the issue of theft and smuggling of nuclear materials need to be developed. This study examines the perpetrators on the supply and demand sides of nuclear smuggling cases and the data regarding their availability to use in new methodologies. Methodological recommendations made in this paper are applicable because the International Atomic Energy Agency (IEAE) could gain access to data sources or conduct researches identified in this study.

1. Nuclear Theft and Smuggling Cases

Illicit trafficking of nuclear and other radioactive material surged as a serious international concern after the collapse of the former Soviet Union in 1991. The degradation of economic and social conditions in the newly established states of the former Soviet Union has created a favourable environment for nuclear theft and smuggling cases (Zaitseva, 1999). Although most of these smuggling and theft cases seem trivial, several of them are not random and opportunistic. They are orchestrated by professionals whose well established smuggling networks, facilitated by corruption, have the capacity to move a significant amount of diverse contraband (Shelley, 2006).

According to Stanford database, about 500 kg of LEU was stolen from research and production facilities, mostly in the former Soviet Union, between 1991 and 2001. Although most of these materials have been recovered as a result of police and intelligence operations, a significant portion of thefts may have gone unnoticed due to poor accounting practices (Zaitseva and Hand, 2003). Moreover, the US authorities have confirmed that a certain amount of nuclear materials have reportedly been diverted from nuclear facilities (Shelley, 2006).

1.2. Supply and Demand Sides

The debate that began with the emergence of nuclear weapons at the close of World War II continues today, including daunting indications that a black market in nuclear-weapons materials may have sprung up. New approaches are needed for viewing nuclear weapons in the post-war era. In particular, the circumstances that influence the supply and demand for nuclear weapons have changed substantially (Zaitseva and Hand, 2003).

Two different groups play an important role in theft and smuggling cases: a) The supply side consisting of people with access to nuclear and other radioactive material. It can be subdivided into civilian employees at source facilities, ranging from technicians to top managers; military personnel; and security guards. Intermediaries –traffickers and middlemen- can be categorized as amateurs, opportunist businessmen and firms, and organized crime. b) The demand side consists of nation states, terrorist organizations, and other groups such as religious sects and separatist movements (Zaitseva and Hand, 2003).

1.2.1. Supply Side

The supply side consists of individuals who have, or can gain, access to nuclear and other radioactive material (Lee, 2006). These individuals can be both insiders and outsiders. Insiders are civilian employees at facilities, military personnel, and security guards.

Insiders:

Thefts involving insiders are most common, especially for nuclear material because they know the vulnerabilities of the facility's accounting system and can use them to their advantage. Detailed knowledge of the facility's security system has also helped insider perpetrators steal nuclear material without being detected (Zaitseva and Hand, 2003).

There have been several reasons that motivate insiders to become involved in theft and smuggling cases: a) The collapse of the Soviet Union caused trouble for nuclear workers who were regarded as one of the elite groups of the nation's science and industry. However, in 1991, the situation changed dramatically for nuclear workers, and most of them encountered a loss of status and lower salaries. Hence, the struggling economy and loose security measures created a favourable environment for material diversion by insiders. b) Court rulings gave rise in the increase of theft cases as insiders who stole nuclear materials were punished unconvincingly. For example, Leonid Smirnov, the first known thief of weapons-grade fissile material, was sentenced to only 3 years probation for the theft of 1.5 kg of HEU. c) The idea of material diversion was prompted by extensive coverage by the mass media. Newspaper reports on nuclear trafficking raised the awareness about the value of such material. d) Pervasive corruption created opportunities for insiders (Zaitseva and Hand, 2003).

Outsiders

According to existing data, outsiders are scarcely involved in the theft of nuclear material. Intermediaries that find a potential buyer for the stolen material play critical roles. They are categorized in three groups: amateurs, opportunist businessmen and firms, and organized crime groups (Zaitseva and Hand, 2003).

Amateurs and Opportunist Businessmen / Firms

Amateurs among outsiders are the most frequently detected subcategory. Usually, they have little or no knowledge about the nature of the material they are handling. They are the least dangerous category of traffickers because they are easier to detect due to their lack of knowledge about the material and where to find the potential customers for this material. On the other hand, some businessmen take advantage of opportunity when offered nuclear material, which they treat as simply an extension of their legitimate activities (Zaitseva and Hand, 2003).

Organized Crime Groups

Despite the fact that a significant amount of smuggling has been committed by opportunists, some cases are linked to criminal groups (Shelley, 2006). To date, there is no concrete evidence to link organized crime groups with nuclear smuggling activities. There have been few confirmed nuclear smuggling activities in which the involvement of organized crime was suspected. However, there is an increasing threat that organized crime potentially is a danger because there exist resourceful and powerful organized crime groups in Russia and Central Asia (Zaitseva and Hand, 2003).

Organized crime groups that are experienced in avoiding detection, knowledge of safe routes, protection by corrupt authorities, and established infrastructures can be exploited in trafficking of nuclear and other radioactive material. For example, one of the suspects arrested in Germany became involved in drug trafficking in 1994 (Zaitseva and Hand, 2003).

The September 11 is considered to be a breakdown point in the potential activities of terrorist organizations. They can use any devastating weapons regardless of serious consequences. One of them is to use nuclear materials. Paramount importance has been given to potential activities of terrorist organizations. At this juncture, Russian organized crime is regarded as the most dangerous one which could traffic these materials for Al-Qaeda or any other terrorist organizations (Shelley, 2006). Two persons who have raised serious concerns were an Israeli businessman of Ukrainian origin and a former Soviet Union officer who had connections with Al-Qaeda. Ties between organized crime and former and active intelligence officials have increased the risk of undetected nuclear smuggling (Lee, 1999).

Additionally, other organized crime groups can have interests in nuclear trafficking. Italian organized crime members were arrested in an attempt to sell nuclear materials smuggled from South Africa in 1998 (Zaitseva and Hand, 2003).

1.2.2. Demand Side

To date, the true dimensions of the nuclear smuggling business and its implications are ambiguous. Arrest and seizure of nuclear materials provide little evidence of participation in the market by rogue states, terrorist organizations, and major organized crime syndicates. However, the observed reality of the traffic could be misleading. For example, a small fraction of drugs are seized as opposed to the huge amount that is circulated internationally. Some significant seizures go unreported, particularly in the former Soviet States. On the demand side, evidences indicate that a handful of nation-states and terrorist organizations are active. More concretely, the North Korea, Iran, and Al-Qaeda are significant threats in demand-side (Lee, 2006).

Proliferating States

The greatest threats are those posed by nation-states with clandestine nuclear weapon programs. Iran, Iraq, and the North Korea have all been debated internationally as nations seeking weapons of mass destruction. In the Stanford database, they are the most frequently reported destinations for the smuggled nuclear and radioactive materials (Zaitseva and Hand, 2003).

Another danger arising from proliferating states is that high government officials covertly transfer strategic nuclear goods to client states or groups either for personal gain or as a matter of policy. The Pakistani scientist A.Q.Khan is the example of the latter. Khan pioneered the centrifuge enrichment program that enabled Pakistan to produce nuclear arms. Khan is known to have sold key components of a nuclear weapons program, including uranium enrichment technology and hardware, to Iran, North Korea and Libya (Lee, 2006).

North Korea

The North Korea has been under international scrutiny after rejecting to be a signatory to the NPT in the 1990s. In spite of the North Korea's insurmountable economic problems, evidence demonstrates that the North Korea has tended to expand in both strength and capability and has deployed chemical and biological weapons in warheads (Zaitseva and Hand, 2003).

The North Korea was hindered by the US and an agreement was made to stop plutonium-processing in 1993. Prior to this intervention, 13 kg of plutonium had been produced in the North Korea. In addition, it is estimated that the North Korea may have been able to extract enough plutonium for 10 warheads from spent nuclear fuel rods. Also, the North Korea made a test of its Taepo Dong-1 multistage missile that demonstrated a 2,000 km range. Therefore, US National Intelligence Council assesses North Korea as one of the most serious imminent threats to the US (Zaitseva and Hand, 2003).

Another factor which makes the North Korea more threatening is its efforts to be an address for smuggled nuclear materials. In 1993, 4.4 tons of Beryllium were intercepted in Lithuania, which have been believed that it was destined to North Korea. According to IAEA report, the captured Beryllium contained 50 percent highly enriched Uranium (Zaitseva and Hand, 2003).

Iran

Iran is another worrisome country in terms of its established nuclear program and technical infrastructure. Reports from the early 1990s indicated that Iran had more than 200 scientists and more than 2,000 technical personnel attributed to nuclear search (Zaitseva and Hand, 2003)).

Several reports show that Iranian intelligence agents have been actively engaged in clandestine procurement of nuclear material and technology. In 1993, Turkish police arrested several smugglers together with three Iranian secret service agents with 2.5 kg Uranium. In another case transpired in 2000, the Kazakhstan police arrested three suspects with 4 kg of LEU fuel pellets which were destined to Iran (Zaitseva and Hand, 2003).

Iran is estimated officially to be 5 to 10 years away from a nuclear weapon according to projections of its centrifuge enrichment capability. However, Iran could shorten this time frame by acquiring HEU or plutonium via black market channels (Lee, 2006).

Terrorist Organizations

The events of September 11, 2001, clearly grabbed the world's attention on the capabilities of terrorist organizations. It was the only time several individuals had caused such a devastating consequence. September 11 attacks proved that terrorist organizations would not abstain from using any nuclear materials if they had possessed. As of this goal, leaders of terrorist organizations declared their propensities to reach nuclear materials (Lee, 2006).

Government studies have repeatedly concluded that a terrorist group which has technical capacity could make a crude nuclear bomb as long as it reaches to nuclear materials (Bunn, 2006). More concretely, the fact that the Al Qaeda terrorist organization attempted to have nuclear materials indicates that uncontrolled nuclear proliferation through theft and smuggling cases have yielded unintended consequences. According to US authorities, it is confident that al Qaeda is pursuing nuclear, chemical, and biological warfare capabilities (Zaitseva and Hand, 2003).

Several incidents indicate Al-Qaeda's long-term interest in reaching nuclear materials. According to statements of a Sudanese national and Al-Qaeda defector, he played a key role in laying the foundation for a 1,5 million dollars purchase of unknown quantity of Uranium which was allegedly brought from South Africa. Law enforcement and counterterrorist operations have

disrupted several suspected plots by Al Qaeda-affiliated groups to use chemical and biological agents in: (1) Rome, in 2002, when authorities disrupted a plot to poison the water supply of the U.S. Embassy in Rome with cyanide; (2) London, in 2003, when the police raided what was thought to be a cell of Al Qaeda suspects intent on producing ricin poison; and (3) Amman, in 2004, when the Jordanian Intelligence Service seized six trucks wired with explosives and containing 20 tonnes of an unknown chemical reportedly intended to destroy the intelligence service's building, the prime Minister's office, and the U.S. Embassy. Also, Pakistani police in Peshawar confiscated 8 kg uranium of unspecified enrichment from two Afghani nationals who were possibly related to Taliban (Zaitseva and Hand, 2003). Lastly, Al-Qaeda reportedly negotiated with the Chechen organized crime groups to reach the nuclear potential in Russia (Lee, 2006).

Additionally, other terrorist organizations such as Tehranian-based Hezbollah are suspected to have an interest in nuclear materials. In 1999, two suspects were arrested in Lebanon with 6 kg uranium which was planned to reach Iranian Hezbollah terrorist organization (Zaitseva and Hand, 2003).

2. Existing Data Bases

One of the challenges regarding nuclear trafficking is the inaccessibility to reliable data. There are various data sources that have conflicts with each other. So, policies to fight against nuclear trafficking do not work effectively (Zaitseva, 2003). For example, the former Soviet republics have failed to report nuclear smuggling incidents for inclusion in the IAEA's trafficking database (Lee, 2006). Existing data is considered to be misleading because most cases are not included in nuclear smuggling data (Zaitseva, 2003).

Reliability of data is classified in three groups: First, 'high' denotes high credibility of data which is confirmed by IAEA and/or by competent national authorities. Second, 'medium' denotes reasonable credibility of data which is not confirmed by the IAEA but confirmed by local authorities directly involved the incident investigations. Third, 'low' denotes less credible or conflicting data. It should be noted that 80 percent of the incidents recorded in the Stanford Database are in the reliability categories of 'high' or 'medium' (Zaitseva, 1999).

IAEA confirmed 18 incidents of trafficking or other unauthorized uses of highly enriched uranium and plutonium between 1991 and 2001. Only a few of these incidents involved significant quantities of weapons-grade nuclear material (IAEA, 2006). According to the IAEA 2007 Report, the IAEA database confirmed 827 incidents. 224 of these incidents involved nuclear materials, 516 incidents involved other radioactive materials (mainly radioactive sources), 26 incidents involved both nuclear and other radioactive materials, 50 incidents involved radioactively contaminated materials, and 11 incidents involved other materials (IAEA, 2007 Report).

Another reliable data source is the Stanford Database, which includes 700 nuclear trafficking cases occurring between 1991 and 2001. The database includes information about source countries, criminals, and the amount and type of smuggled nuclear material (Zaitseva, 2003).

The Monterey Institute also has a dataset (http://www.nti.org/db/nistraff/index.html) regarding ongoing theft and smuggling cases. The dataset includes all WMD materials stolen or smuggled since 1999. This data set is considered to be one of the most updated because it has cases from 2009. Many scholars use this data set to analyze ongoing theft and smuggling cases.

As indicated above, data sets do not overlap, therefore it is possible to say that there are few confirmed data sources that record WMD trafficking cases. Because countries tend to hide WMD trafficking cases, there is no accessible and reliable data. Therefore, one of the policy implications should be to establish a joint database, which keeps track of all WMD trafficking cases.

3. Various System Methodologies

There are few studies in the literature that examine depth proliferation involving non-state actors using different methodologies. According to Lee (2006), nuclear trafficking is fraught with ambiguity. However, it seems possible to conduct research in order to determine trends and propensities in nuclear trafficking, and to measure what factors are effective in explaining nuclear trafficking and theft cases, or to find correlations between increasing nuclear trafficking and theft cases. Case studies, multivariate statistics, and social network analysis can be used to make research on theft and smuggling of nuclear materials.

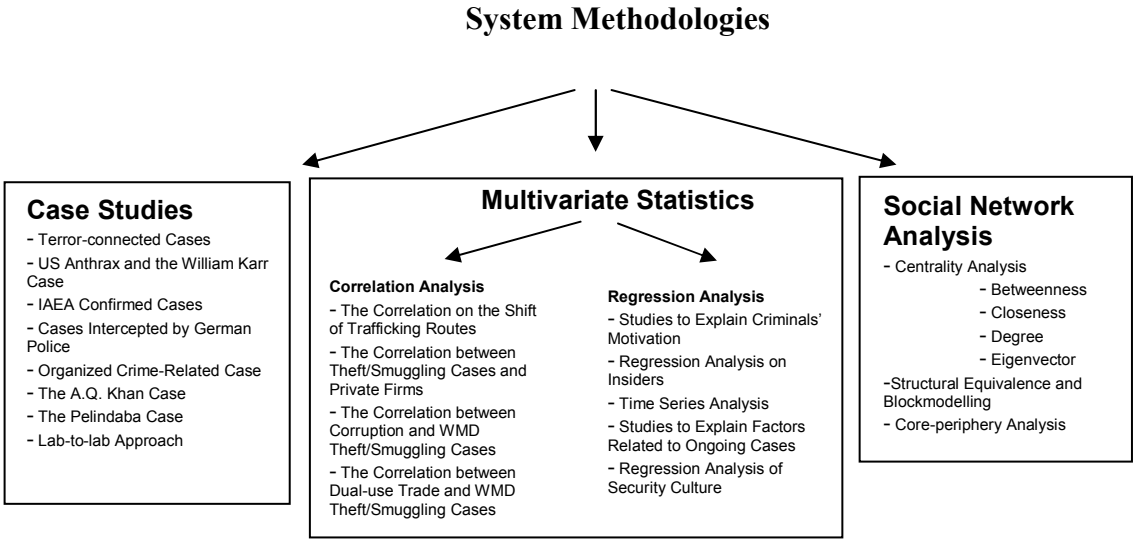

Figure 1: Various System Methodologies to Model WMD Trafficking Cases

3.1. Case Studies

The fact that there are limitations on the reliability of data requires new methodologies. One of them is to use case study technique in order to analyze existing cases and set up linkages with possible cases that could happen in the future.

Terror-connected Cases

To date there is only one international terrorist group that successfully established a WMD infrastructure to weaponize chemical and biological agents. While the Japanese terrorist group Aum Ahinrikyo spent millions in the 1990s establishing a transnational WMD production infrastructure, the group proved only partially successful in producing weaponizable chemical agents. The inherent difficulties in producing chemical, biological, and especially nuclear weapons suggests that violent non-state actors will play a more important role on the demand side of the proliferation market substructure. This is true in today's environment in which Al Qaeda, for example, is rumoured to have repeatedly attempted the purchase of nuclear warheads in Central Asia (CNS, 2005).

The Japanese case needs to be analysed in a 'case study' format. The motives that pushed the terrorist organization to use WMD materials, how they gained access and stored these materials, and how they recruited WMD experts need to be analyzed. The information obtained from this case study can be linked to Al-Qaeda and Hezbollah, and similarities can be found. The Al-Qaeda terrorist organization has the most potential and capability to acquire these materials.

US Anthrax and the William Karr Case

Another case study technique needs to be used in examining the unsolved US anthrax case from 2001 and the William Karr case. A highly trained individual or group of individuals produced, weaponized, and delivered anthrax in 2001. In 2003, Texas investigators discovered a homemade sodium-cyanide bomb in the garage of William Karr, which was capable of killing inhabitants in an enclosed space the size of a small civic centre. The ability of violent non-state actors and/or individuals to construct their own unconventional weapons cannot be dismissed (Axtman, 2008). Therefore, these cases need to analysed in order to determine why these people produced and weaponized these materials, why law enforcement did not detect these cases on time, how these people gained access to these materials etc. The information obtained from these cases would be helpful in detecting and comprehending the propensities of criminals to use these materials.

IAEA Confirmed Cases

IAEA had 18 confirmed nuclear smuggling cases that included nuclear materials between 1991 and 2001 (Zaitseva and Hand, 2003). The fact that these cases are examined individually would be helpful in finding general characteristics of smuggling cases. Differences and similarities among these 18 cases can be detected and new inferences can be made with respect to possible smuggling cases that could happen in the future.

Cases Intercepted by German Police

Effective policing played critical role in detecting nuclear theft and smuggling cases. First, the results of police operations forced the Russian government to acknowledge the leakage of nuclear materials from its facilities. Second, police operations discouraged criminals to attempt to smuggle nuclear materials. Improved border controls in many European countries served as a psychological deterrent to would-be smugglers (Zaitseva, 1999).

How these materials were smuggled to Germany can be examined in a case study format since there is little information in the literature over how these seizures in Germany (Zaitseva, 2003). The information obtained in these cases can be used to strengthen policing in countries that either have nuclear facilities or are located on WMD trafficking routes.

Organized Crime-Related Case

To date there is no concrete evidence to link organized crime groups with nuclear smuggling activities. There have been few confirmed nuclear smuggling activities in which the involvement of organized crime was suspected. According to Shelley (2006), there have been indications that organized criminal groups might be more inclined to accept the risks of nuclear trafficking because of financial gain. Although there was no concrete evidence regarding Russian mafia's involvement in nuclear trafficking cases, one should take note of the arrest of six members of the Balashikha organized crime group who were attempting to sell over a kilogram of nuclear material in 2001. The material turned out to be nuclear fuel pellets enriched to only 2.4 percent U-235 (Zaitseva, 2003).

This case can be examined and its general characteristics can be detected. Why organized crime groups had an interest to sell these materials, how they acquired these materials, how they found buyers, what techniques they used to store these materials, and why law enforcement did not find these materials need to be examined. Results obtained from the study can be used to explain the propensity of organized crime to be a mediator in providing these materials to terrorist organizations.

The A.Q. Khan Case

A.Q. Khan is an example to see the consequences of people who disclose information to others that can jeopardize the world. Currently, Pakistan has the potential to face such cases. The belief is that nuclear scientists could behave like Khan and give information to other countries concerning key components of a nuclear weapons program (Bunn, 2006).

The A.Q.Khan case can be studied in a 'case study' format in order to learn why he sold information to other countries and how he was motivated to share information. Information

obtained from him can be used to make policies aimed at preventing such cases in nuclear weapon states.

The Pelindaba Case

Two teams of armed men attacked the Pelindaba nuclear facility in South Africa, where hundreds of kilograms of weapon-grade HEU are stored. One of the teams of four armed men disabled the detection systems at the site perimeter. No one on either team was shot or captured (Bunn, 2008). According to Bunn (2006), the essential ingredients of nuclear weapons are stored in hundreds of buildings in more than 40 countries. While some of these buildings are very well-secured, some have little more than a watchman and a chain-link fence. The danger of nuclear theft is now recognized as a global problem requiring global solutions, not just a problem of the former Soviet Unions (Bunn, 2006). The case of an attempted break-in at nuclear facilities in South Africa in 2007 provides evidence of this global policy issue.

Therefore, the Pelindaba case needs to be examined in a 'case study' format in order to analyze how criminals successfully entered the facility, why security guards failed to prevent these criminals and what went wrong to secure this security. The implications of this case can be used to make policies to secure nuclear facilities.

Lab-to-lab Approach

One of the challenges in fighting transnational criminal and terrorist networks is the lack of cooperation among countries. Many countries that encounter WMD theft/smuggling cases do not issue them and abstain from cooperating with international organizations. The best way is to coordinate law enforcement in countries in the fight against WMD trafficking. According to Bunn, lab-to-lab was a part of policies made in the framework of Nunn-Lugar program. The aim was to have low-level connections rather than government to government connections. Lab-to-lab was the most effective policy to convince Russia to cooperate in controlling nuclear materials against theft and smuggling cases (Bunn, 2006). Therefore, the lab-to-lab model should be examined in a case study format and information obtained in this study should be used to make policies for an effective cooperation and coordination among the law enforcement units of countries.

3.2. Multivariate Statistics

Correlation and regression analysis can be used to model transnational criminal and terrorist networks involved in WMD trafficking cases.

3.2.1. Correlation Analysis

The Correlation on the Shift of Trafficking Routes

The movement of nuclear materials from the newly established states appears to have shifted southward, to the borders of the Caucasus, Turkey, and Central Asia (Shelley, 2006). Several factors play a key role in this shift: First, this route is closed to the Middle East and South Asia where states and terrorist organizations that are most likely customers for stolen nuclear materials are located. Second, the region has been intensively used by other types of smugglers since 1991. Third, border controls in these regional countries are lax, and government officials often corrupt. Consequently, the southern tier seems a more logical location for smuggling nuclear materials. The sharp increase in the number of smuggling cases detected on this route confirms the diversion toward the southern tier (Lee, 1999).

A correlation analysis between the number of smuggling cases in a country and its demographics would be helpful in detecting factors that have led to the change of routes. The number of smuggling cases in a country can be correlated to GDP, educational attainment, the number of terrorist organizations, the number of organized crime groups, etc. The data with respect to the demographics of countries can be obtained from the World Bank web page.

The Correlation between Theft/Smuggling Cases and Private Firms

Countries in transition to a market economy have given importance to privatization. Many governmental institutions and services have been taken over to the private sector in these countries. However, these countries are exposed to profound consequences of organized crime and corruption (Volkov, 2002). As a result, it is clear that countries in transition that have undergone privatization have encountered organized crime and corruption issues. In this respect, Russia and newly established countries are examples of how privatization has given rise to the strengthening of organized crime and corruption (Varese, 2005). Private firms have played a key role in the storage and shipment of nuclear materials. According to O'Neill (1999), one of the important features of the new political landscape surrounding the transport of nuclear materials is the growing involvement of private firms. Shipping companies add an additional layer of responsibility to an already complex picture (O'Neil, 1999). According to Bunn (2008), insufficient systems for accounting and control of nuclear materials and the emergence of private firms in Russia has led to a dramatic increase in theft attempts.

It can be inferred that there is a great risk in transition countries because organized crime and pervasive corruption can influence private firms. Organized crime easily gains access to these materials by proffering bribes to private firms (Bunn, 2006). Therefore, it could be useful to find out to what extent private firms are reliable for the storage and shipment of WMD materials. Theft/smuggling cases in a country and private firms that are responsible for storing and shipping these materials can be correlated. It is most probable that the correlation, in corrupt countries, would be positively higher. That is, the more private firms store WMD materials, the more probable they could be stolen or smuggled. As a result, the policy implication could be that these materials should be stored by states.

The Correlation between Corruption and WMD Theft/Smuggling Cases

Transnational nuclear networks in Russia and newly established states have had access to huge nuclear stockpiles which are badly protected through scientists and corrupt insiders (Shelley, 2006). Traffickers may simply bribe border officials to turn off or ignore the sensors (Lee, 2006). Despite US-funded efforts to interdict nuclear smuggling and theft cases, the challenge will be daunting in view of the widespread corruption in the former Soviet Republics (Zaitseva, 1999). The Corruption Perception Index ranks Russia, Ukraine, Belarus, Pakistan, North Korea, Iran and South Africa as among the most corrupt countries in the world. Underpaid public officials working in nuclear facilities in these countries may consider it "their right" to better their financial situation (Bunn, 2008).

A correlation analysis can be made to examine the relation between corruption and WMD theft and smuggling cases. The data can be obtained from the Corruption Perception Index 2008 report and the Monterey Institute web page. Subsequent to the study, new policies that focus on reducing the effects of corruption on theft and smuggling cases can be made.

The Correlation between Dual-use Trade and WMD Theft/Smuggling Cases

There is a consensus that dual-use nuclear materials and technologies are considered to be threatening for the future (Morstein and Perry, 2000). Every component of a nuclear weapon and its production has a dual-use. Each component can be used for peaceful purposes such as commercial nuclear energy, research or other industries, or for a non-peaceful purpose such as the construction of a nuclear weapon or nuclear weapons arsenal (Morstein, 1999).

According to Morstein and Perry (2000), proliferant nations that have used the commercial nuclear energy market tend to procure the materials and technologies needed to make nuclear weapons (Einborn, 2006). All suspected nuclear-aspiring nations shop for nuclear dual-use materials in a similar manner. They develop for themselves trade connections designed to hide their intentions while securing their access (Morstein and Perry, 2000). Dual use materials and technologies are critical in proliferation. They pose serious challenges such as their diversion during storage and shipment through organized crime (Morstein, 1999). The lesson from Russia is that stored nuclear materials have been stolen or smuggled from nuclear facilities. It is probable

that corrupt countries that store and ship these nuclear materials would have some nuclear trafficking cases (Bunn, 2008).

According to Morstein (1999), a systemic approach to the study of the dual-use nuclear trade is appropriate and feasible because it helps to the study of nuclear proliferation by detecting the structure of the system. While the traditional approach to the study of nuclear proliferation focuses on the capabilities and intentions of nations that tend to acquire nuclear weapons, the systemic approach is more concerned with the trade interactions between nations (Morstein, 1999). In this respect, correlation analysis between dual-use trade and trafficking should be done. The data can be obtained from the Stanford Data Base or the Monterey Institute web page. Countries that are involved in dual-use trade and have nuclear trafficking cases can be analyzed in correlation analysis. It seems that countries involved in dual-use have more theft and smuggling cases because this trade can create opportunities for criminal networks in the process of storage and shipment.

3.2.2 Regression Analysis

Studies to Explain the Motivation of Criminals

The only information about nuclear smuggling cases intercepted in Germany is that German police arrested criminals in police sting operations. There is a need to learn more details about criminals. Regression analysis can be used to explain factors that motivate criminals to become involved in these cases. The dependent variable can be the number of nuclear smuggling cases, and independent variables can be the nationality of criminal (Dummy variable, 1: from source country and 0: not from source country), criminals' economic status, family situation, age, and marital status, and etc. As a result, the information can be used to make policies to increase the functionality of policing. The policy implication can be the establishment of specialized and professionalized police unit whose responsibility is only to fight nuclear trafficking. Profiling of criminals can be gained from this study as well.

Regression Analysis on the Motivation of Insiders

Other research can be done on workers or public officials in nuclear facilities in order to determine factors that have led to involvement in theft and smuggling cases in terms of insiders. In such research regression analysis can be used. The dependent variable can be the number of theft cases that insiders are involved in; the independent variables can be monthly salaries of insiders, their educational attainment, the average number of guards in a nuclear facility etc (Lee, 2006). Survey data can be used in this study.

Studies to Explain Factors Related to Ongoing Cases

Whereas there is no indication that violent non-state actors have become involved in nuclear materials trafficking cases, the number of existing theft and seizure cases is an indicator of ongoing potential threat. Table 2 shows some of the thefts and seizures during 2007, 2008, and 2009 in the newly established states.

Table 1: Selected theft and seizures among over 100 incidents occurred in the newly established states in 2007, 2008 and 2009

18 February 2009	Cargo from Lithuania containing radioactive waste detained in Krasnodar
25 December 2008	Two men convicted for smuggling uranium
22 December 2008	Five men convicted for stealing uranium from the Chepetsk Plant in Russia
1 September 2008	Moldova-bound train with radioactive cargo passes through Kazakh borders undetected
9 September 2008	Three individuals arrested for smuggling depleted uranium from Kyrgyzstan to China
30 May 2008	Ukrainian law enforcement officials arrest smugglers of radioactive scrap metal
14 March 2008	Truck with radioactive sand detained at Belarusian-Polish border
28 January 2008	Individual suspected of financing nuclear trafficking arrested in Russia
29 November 2007	Ukrainian police seizes mercury and cesium-137 from individual
13 November 2007	Belarusian customs officials detain trucks with elevated radiation cargo

Source: The NIS Nuclear Trafficking Database, http://www.nti.org/db/nistraff/index.html

Another study can be done to explain the propensity to steal or smuggle WMD materials stored in source countries. Using data given in the Monterey Institute web page, a regression analysis can be made. The dependent variable is the number of theft and smuggling cases, and the independent variables are demographics of countries such as GDP, educational attainment, age, and crime-related variables such as the number of organized crime groups, the number of terrorist organizations etc.

3.3. Social Network Analysis

The general information about WMD trafficking is that these materials have been trafficked from source countries that have nuclear facilities to destination countries that have a demand for these materials. Detailed information about other countries located on trafficking routes as well as potential source and destination countries need to be analyzed (Bunn, 2006). According to many scholars, social network analysis is a decent method to explain international trade and smuggling relations (Scott, 2005).

Social network analysis focuses on the use of graphical depictions or maps to present the configurations of connections between actors in the network. This graphical approach allows the analyst to identify visually key relationships between specific nations and groups of nations in the system (Wasserman and Faust, 1994).

According to Morstein and Perry (2000), determining which nations have positions that exert the most influence in the trafficking network can be helpful in understanding the sensitivities of the system and identifying the actors towards which policies should be directed. Similarly, determining source and destination countries in terms of WMD trafficking as well as countries located on the trafficking route can be useful to specify international policies in the fight against nuclear proliferation. Analysis of the trafficking routes requires a methodology specifically

designed for understanding relationships and the subsequent position of nations in a complex network. Social network analysis is a generic systems analysis methodology that provides the analytic approach needed to comprehend the dynamics of the global nuclear market (Morstein and Perry, 2000). As a result of social network analysis, when states are detected in terms of their position in trafficking cases, policies can be developed to address these nations. This identification yields a better comprehension of how these nations play important role in trafficking of nuclear materials.

At this juncture, in her article Zaitseva (2003) uses 700 illicit trafficking incidents collected by the Stanford Database on Nuclear Smuggling. This data set can be used in order to determine smuggling networks using social network analysis. Or the data set recorded by the Monterey Institute web page and shared in its web page can be used.

Centrality Analysis

The maps in social network analysis explaining the network in a group can be helpful to see a general panorama, but for more complex networks the maps are more difficult to interpret. In these cases, centrality measures provide a means to interpret the data. That is why three types of centrality measures can be used in a study (Morstein and Perry, 2000).

a) Degree Centrality: This centrality gives the actor that has the most connections to others (Morstein and Perry, 2000). In a study used with the Stanford database, degree can be the country that has more theft/smuggling cases.

b) Betweenness Centrality. This centrality gives the actor that is the middleman with the power to control flow of information between the most other actors (Morstein and Perry, 2000). In a study, betweenness can be the country that helps the transportation of stolen or smuggled materials. It is probable that betweenness countries would be located on trafficking routes because criminals in these countries provide coordination of criminals that are located in source and destination countries in terms of WMD materials.

c) Closeness Centrality: This gives information about the actor that is the most connected to every other actor in a group (Morstein and Perry, 2000). It is more probable that closeness countries would be destination and source countries because criminals in these countries make contact with others who could be intermediaries in trafficking cases.

d) Eigenvector Centrality: It is a measure of the importance of a node in a network. It assigns relative scores to all nodes in the network based on the principle that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes (Wasserman and Faust, 1994). As a result of this measure, countries that have critical importance can be detected, and policies can be exclusively made for those countries.

Structural Equivalence and Blockmodelling

While structural equivalence analysis relies heavily on the combination of key actors according to similar attributes, 'blockmodelling' groups actors into structurally equivalent positions (Wasserman and Faust, 1994). These measures can also provide core-periphery analysis, clustering nodes in two main groups (Scott, 2005). 'Structural equivalence and blockmodelling' in network analysis can be used to cluster states in terms of their position in trafficking of nuclear materials. Core-periphery analysis can give information about core and periphery countries in terms of WMD trafficking. This classification would be helpful to make policies because different policies are needed for countries in the core group.

Conclusion

The world has experienced depth proliferation involving non-state actors such as terrorist groups and organized criminal groups. There have still been leakages from nuclear facilities through either theft or smuggling cases. Effective policies are needed to fight existing theft and smuggling cases. However, because of issues stemming from the reliability and accessibility of

datasets regarding these cases, new studies that can be used to make policies encounter challenges.

Currently, the IAEA has the most reliable data set, but the belief is that there are a number of missing cases because countries tend to hide WMD trafficking cases. Also, the Stanford University and the Monterey Institute have databases of WMD trafficking cases. Although there have been some conflicts between data sources, these data sets are considered reliable. Data accessibility is another issue. Access to these data sources is limited.

New studies using various methodological systems are needed to make effective policies. The data sources indicated above, along with survey data, can be used in these studies.

First, case study technique can be used. Cases that are unique and have similarities with cases that could happen in the future can be selected and studied. More concretely, some of case studies can be about the Pelindaba Case, the A.Q.Khan Case, or the Lab-to-lab approach. Second, correlation and regression analysis can be used in order to analyze dual-use trade, the effects of corruption, and the role of private firms. Third, social network analysis can be used to analyze the position and role of countries that have nuclear materials or are located WMD trafficking routes. Information obtained from these methodological studies can be used in policy analysis, and effective policies can be mad*e*.

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