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Rogue proliferator? North Korea's nuclear fuel cycle & its relationship to regime perpetuation

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ABSTRACT

North Korea is unlikely to relinquish its nuclear program because of its importance to the perpetuation of the Kim regime. This conclusion arises from the observation that the nuclear program has been a long-term project spanning several decades, culminating in denuclearisation negotiations, which have followed a cyclical pattern in which the North has provoked crises to extract concessions and gain leverage vis-a-vis regional states. It is clear that the nuclear program has great intrinsic value to Pyongyang. First, this paper argues that the sunk costs of previous investment in the nuclear program, as evidenced by the infrastructure for the country's nuclear fuel cycle, create forward momentum favouring continuation of the nuclear program. Second, it argues that the nuclear program solidifies Kim regime rule as an institutional buttress, as a prop for the domestic economy, and as a vehicle for ideological legitimation. The paper is a unique contribution, which explicitly links the Kim regime's proliferation calculus to the economic and bureaucratic imperatives of regime perpetuation, as well as the sunk cost of previous investment in the nuclear program. It provides a coherent explanation for North Korea's consistent unreliability in negotiations, and offers insights into future prospects of the denuclearisation process.

1. Introduction

The motivations for North Korea's nuclear proliferation are not comprehensible without an understanding of the technical aspects of the nuclear program itself. Observers often refer to nuclear dismantlement as if it were something the North could perform very rapidly. By examining the physical extent of the program, it becomes clear that it is not the case. In a very real way, the physical plant of the program, the nuclear infrastructure, is embedded in the national economy, which becomes clear when considering the numerous complex industrial processes of the North's nuclear fuel cycle. By understanding the technical aspects of the Kim regime's nuclear capability and the motivations for its nuclear proliferation, one can successfully locate the program within the political economy of the DPRK state and evaluate its importance to the institutional maintenance of the North's unique political system.

The paper provides readers with an understanding of integration of North Korea's nuclear program into the political economy of the DPRK state. It aims to demonstrate how North Korea's nuclear fuel cycle, with its associate bureaucracy, are integral economic survival, political stability and ideological legitimation of the Kim regime. In this regard, it is a unique contribution to the academic literature, which explicitly links the Kim regime's proliferation calculus to the economic and bureaucratic imperatives of regime perpetuation, as well as the sunk cost of previous investment in the nuclear program. In doing so, it provides a coherent explanation as to why North Korea has consistently proven to be an unreliable negotiating partner, and offers insights into future prospects of denuclearisation negotiations. Using this information, policy-makers should re-evaluate the practicality of a negotiated settlement as an instrument to secure the dismantlement of North Korea's nuclear program, in favour of a strategy for constructive management of Northeast Asian security in light of North Korea's ascension as a nuclear power.

This research focus is important because it comes at a time when the evolution of political dynamics in Northeast Asia is beginning to accelerate. China's growing role as a centre of power is occurring as the United States begins to diminish as a global superpower. In Japan, tension exists between its historic pacifist posture under US protection and pressure from the political right to return Japan to a more active and 'normal' strategic posture. Internationally, the global financial crisis, energy insecurity and climate change are emerging challenges to regional stability, despite the difficulty in calibrating their precise long-term impacts. In this context, old denuclearisation strategies have

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become obsolete. To improve regional political and economic stability, regional states must acknowledge the wide-ranging imperatives driving North Korea's nuclear proliferation. The intellectual task of nesting the technical understanding of North Korea's nuclear fuel cycle within the context of the Kim regime's motivations for proliferation is integral to this objective.

The first section will describe North Korea's nuclear fuel cycle in order to document the physical extent of the nuclear program. The second section addresses the quest for weaponisation of the nuclear program, including miniaturisation, testing and potential delivery systems. The third section explores the domestic political economy considerations driving Pyongyang's nuclear calculus, incorporating economic, institutional and ideological factors. The inescapable conclusion is reached that North Korea is unlikely to relinquish its nuclear program because no suite of incentives on offer from the international community can match its utility in maintaining the rule of the Kim regime.

2. North Korea's nuclear fuel cycle

The nuclear fuel cycle consists of a number of complex industrial processes through eight specific stages. This analysis demonstrates the resource inputs, industrial hardware and technical expertise necessary to maintain the nuclear program, as well as the geographic dispersion of important nuclear sites. While Yongbyon clearly is the epicentre of the nuclear operation, other important nuclear-related facilities are located around the country. As will be made clear, it is unrealistic to expect hasty dismantlement of the nuclear infrastructure, regardless of any denuclearisation agreement.

2.1. Uranium mining and milling

North Korea is endowed with extensive uranium ore deposits, which constitute the prerequisite feedstock of the nuclear fuel cycle. Surveys conducted during the 1970s suggest that North Korea at that time possessed ~300,000 tons of uriniferous black shale ore, at concentrations of around 0.2% uranium, located at depths of about 200 m (Hayes 2004). Today, large-scale uranium mine sites in North Korea include Sunchon in South Pyongan province, Kusong, in North Pyongan province, Unggi in North Hamgyong province, Pyongsan in North Hwanghae province, and Pakchon in South Hamgyong province (Nuclear Threat Initiative 2007). North Korean mines use two uranium ore extraction techniques; open cut mining is used when the ore body lies at a shallow depth, while underground mining techniques at employed when the ore deposit is greater than 120 m deep (Hayes 2004; Hore-Lacy 2004, p. 317).

Uranium milling facilities are generally located close to the ore body. North Korea's uranium milling facilities are located at Sunchon, Pyongsan and Pakchon, close to uranium mines in those areas (Global Security 2006a, b). The extracted ore must be milled to concentrate the uranium in a form more practical for industrial processing because of the low concentration of uranium in the ore body (as little as 0.2%). The milling process crushes the ore into a powder, which is then filtered through a strong acid or alkaline solution to leach the uranium from the ore fragments. The leached uranium is precipitated from the solution then dried and heated to produce a concentrate of uranium oxide, known as yellowcake, which contains ~80% uranium. The remainder of the ore is waste tailings consisting of radioactive materials and toxic heavy metals that need to be stored in isolation from the wider environment (Landa, 2004, 1–2). One ton of North Korean uranium ore contains ~1 kg of uranium, which means that 50,000 tons of uranium ore had to be mined and milled to extract the 50 tons of uranium required for the initial fuel load for the 5 MW(e) reactor at Yongbyon. At peak production in the early 1990s, before the 1994 freeze under the Agreed Framework, North Korea was able to produce about 300 tons of yellowcake annually, from ~30,000 tons of ore (IISS, 2004, p.33).

2.2. Uranium conversion and enrichment

2.2.1. Conversion

Ordinarily yellowcake must be processed into uranium hexafluoride, then fed into a uranium enrichment process to increase the proportion of the isotope uranium-235 (^{235}U) in the final fuel load (Makhijani et al., 2004, pp. 32–33). Most reactors operating around the world today require enriched uranium for fuel. However, the 5 MW(e) [MW(e)=megawatts of electric output] reactor at Yongbyon is a gas-cooled graphite-moderated model, based on the UK's Calder Hall plutonium production reactor, which is capable of using fuel fabricated directly from unenriched natural uranium (Hayes, 2004; Kokoski, 1995, p. 12). This was advantageous to the North Koreans because the materials, technology and equipment for uranium enrichment would have had to be imported from abroad (Hecker and Liou, 2007. p. 7). Skipping the enrichment step was not only cheaper and more practical, but also allowed the front end of the fuel cycle to remain an indigenous operation.

North Korea has mastered the processing of yellowcake to uranium dioxide and then into uranium tetrafluoride, which is the precursor step to conversion into uranium hexafluoride, the feedstock for uranium enrichment (Hecker and Liou, 2007, p. 8). A reported export of 2 tons of uranium to Libya from North Korea in 2004 raised concerns that a uranium hexafluoride conversion process had been mastered at Yongbyon, though it is unclear whether the export load was delivered as yellowcake or as uranium hexafluoride. If it was the latter, it means the North has developed the expertise for full uranium conversion and has mastered the prerequisite step for uranium enrichment (Hayes 2004). However, IAEA inspections of the Yongbyon fuel fabrication plant prior to 2003 found no evidence of the equipment needed to produce uranium hexafluoride (Hecker and Liou, 2007, p. 8). The existence of a full conversion process at Yongbyon, or elsewhere in North Korea, remains a matter of debate.

2.2.2. Uranium enrichment

Natural uranium primarily consists of two isotopes: ^{235}U and ^{238}U. Of the two, only ^{235}U is fissile, though it constitutes only 0.7% of the natural uranium load. Uranium must be enriched to ~2–4% ^{235}U for use as fuel in light water reactors and to over 90% as highly enriched uranium (HEU) for use in nuclear weapons (Makhijani et al., 2004, p. 5). As North Korea does not have any operational light water nuclear reactors, any uranium enrichment activity is likely be devoted specifically to the production of fissile uranium for nuclear weapons.

There are two enrichment processes currently in commercial use around the world: gaseous diffusion and gas centrifuge, which both use uranium hexafluoride as a feedstock and both use the different molecular weights of ^{235}U and ^{238}U to separate the isotopes. Gaseous diffusion requires a massive "cascade" of at least 1200 diffusion stages, where each stage enriches the uranium slightly more to produce 3% ^{235}U reactor-grade uranium. Over 4000 stages are required to produce highly enriched weapons-grade uranium using this technique (Kokoski, 1995, p. 63). Gaseous diffusion facilities in the United States and Europe are enormous, requiring physical space, equipment and substantial energy inputs that are not available in North Korea. If the North did establish such a facility, its size and energy signature