A Roadmap for DPRK's Denuclearization Under the Consideration of Nuclear Latency

Korean Nuclear Society Spring Meeting

13 May 2021

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I. Introduction

1. Background

① Prolonged deadlock between the US and DPRK

Tension after Singapore Summit (2018)
Failure of Hanoi Summit (2019. 2.)
Failure of working group talks in Stockholm (2019. 10.)

AP, 2018.

② The new administration office in the US

Review of North Korea policy (April 2021)
Outlining “Calibrated and practical” approach in a deal
Expected to pursue phase-by-phase approach to North Korea’s denuclearization

AP, 2020.

③ Severe economic crisis in North Korea

Blocked China-DPRK trade for disinfection against COVID-19 (2020)
Flood damage and the reconstruction process (2020)
Prolonged US, UN sanctions

AFP, 2020.

I. Introduction

2. Motivations and Goals

① New approach toward the denuclearization is required

"A political strategy, accompanied by *incremental steps* to contain North Korea's nuclear program, may sound unpalatable, but previous approaches have not worked (Cha, 2020)."

Chosunilbo, 2018.

② Consideration of Nuclear Latency

Focusing on the process of advancing nuclear capabilities
Fitted to a phase-by-phase transaction scenarios
Denuclearization as: conversion of military weapons into civilian energy

A → 0

A → B

③ How to downgrade nuclear latency level

Denuclearize by incrementally grading down nuclear latency level
Factors determining North Korea's nuclear latency level
How to limit advancement of its latency level

I. Introduction

3. Literature Review

① Concept of Nuclear Latency

Having technological capabilities (e.g. ENR),
but not yet developed nuclear weapons (Whitlark and Mehta, 2019)
More common than nuclear proliferation (Fuhrmann and Tkach, 2015)

② Existence of a "sweet spot" among nuclear latency level

"Strongest position to extract a concession from the United States"?
Empirical study to find out a sweet spot in nuclear latency level
Upper boundary between operation stage and scale-up level of ENR facilities (Volpe, 2017)

③ Existence of a "danger zone" among nuclear fuel cycle level

Introduction of Nuclear Fuel Cycle (NFC) index
Defining a "danger zone" based on the NFC level
States passed through the danger zone are unlikely to proliferate (Herzog, 2020)

II. Methods

1. North Korean Nuclearization Dataset (1992-2018)

A comprehensive technical and political history of North Korea's nuclear program over the past 26 years (Hecker and Carlin, 2018)

	US Diplomacy	DPRK Diplomacy	DPRK/ROK Relations	DPRK/PRC Relations	US Presence at Yongbyon	Plutonium	Uranium Enrichment	Tritium/Li-6	Weaponization	Nuclear Weapons (Summary)	Missiles (Summary)	Import	Export	Sanctions	North Korean Economy	US Financial Aid (Millions)
1992	G1	G1	G3	R2	G1	G2	G1	G1	R1	R1	R1	R1	R1	R1	R2	$0
1993	G2	G2	G2	R1	G1	G2	G1	G1	R1	R1	R1	R1	R1	R1	R2	$0
1994	G3	G3	R2	R1	G1	G2	G1	G1	R1	R1	R1	R1	R1	R1	R3	$0
1995	G3	G3	R1	R1	G3	G3	G1	G1	R1	G3	R1	R1	R1	R1	R3	$9.70
1996	G3	G3	R1	R1	G3	G3	G1	G1	R1	G3	R1	R1	R1	R1	R3	$30.30
1997	G2	G2	G1	R1	G3	G3	R1	G1	R1	G3	R1	R2	R1	R1	R3	$82.40
1998	G2	G2	G1	R1	G3	G3	R1	G1	R1	G3	R1	R2	R1	R1	R3	$122.90
1999	G3	G3	G3	G1	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R3	$287.20
2000	G3	G3	G3	G2	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R2	$138.70
2001	R2	G2	G1	G2	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R2	$132.97
2002	R3	G2	G2	G2	G3	G3	R1	G1	R1	G3	G1	R2	R3	R1	R2	$140.90
2003	R2	R2	G1	G2	R3	R3	R1	R1	R2	R2	G1	R2	R3	R1	R1	$27.78
2004	R2	R1	R1	G1	R3	R3	R1	R1	R2	R2	G1	R2	R3	R1	R1	$36.40
2005	R1	R1	G1	G1	R3	R3	R1	R1	R2	R2	R1	R2	R3	R1	R1	$5.70
2006	R1	R2	G1	R1	R3	R3	R1	R1	R2	R2	R1	R2	R3	R1	R1	$0
2007	G2	G1	G3	R1	G3	G1	R1	R1	R1	R1	R1	R1	R3	R1	R1	$45.10
2008	G2	G1	R1	G1	G3	G1	R1	R1	R1	R1	R1	R1	R2	R1	R1	$224.70
2009	R1	R1	R2	G1	R2	R1	R2	R2	R2	R2	R1	R2	R2	R1	R2	$24.60
2010	G1	R1	R3	G2	R3	R1	R2	R2	R2	R2	R1	R2	R2	R1	R1	$3.50
2011	G1	G1	R3	G2	R3	R1	R2	R2	R2	R2	R1	R2	R2	R1	R1	$0.90
2012	R1	R1	R3	G2	R3	R1	R2	R2	R2	R2	R1	R2	R2	R1	G1	$0
2013	R2	R1	R2	R2	R3	R2	R2	R2	R2	R2	R1	R2	R1	R2	G1	$0
2014	R2	R1	R2	R2	R3	R2	R3	R3	R2	R2	R2	R2	R1	R2	G1	$0
2015	R1	G1	R2	R2	R3	R3	R3	R3	R2	R2	R2	R2	R1	R2	G2	$0
2016	R1	R3	R3	R2	R3	R3	R3	R3	R3	R3	R3	R2	R1	R2	G2	$0
2017	R3	R3	R2	R2	R3	R3	R3	R3	R3	R3	R3	R2	R1	R3	G2	$0.90

Hecker and Carlin, 2018.

II. Methods

2. Quantification

Code the color chart for quantification

G3 -> +2.5

G2 -> +1.5

G1 -> +0.5

R1 -> -0.5

R2 -> -1.5

R3 -> -2.5

Year	USDiplom	DPRKDipl	DPRK/RO	DPRK/PR	US Prese	Plutonium	UraniumE	Tritium/Li	Weaponization	Missiles(S	Import	Export	Sanctions	North Kor	US Financ	Nuclear W
1992	0.5	0.5	2.5	-1.5	0.5	1.5	0.5	0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.5	0	-0.5
1993	1.5	1.5	1.5	-0.5	0.5	1.5	0.5	0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.5	0	-0.5
1994	2.5	2.5	-1.5	-0.5	0.5	1.5	0.5	0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-2.5	0	-0.5
1995	2.5	2.5	-0.5	-0.5	2.5	2.5	0.5	0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-2.5	9.7	2.5
1996	2.5	2.5	-0.5	-0.5	2.5	2.5	0.5	0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-2.5	30.3	2.5
1997	1.5	1.5	0.5	-0.5	2.5	2.5	-0.5	0.5	-0.5	-0.5	-1.5	-0.5	-0.5	-2.5	82.4	2.5
1998	1.5	1.5	0.5	-0.5	2.5	2.5	-0.5	0.5	-0.5	-0.5	-1.5	-0.5	-0.5	-2.5	122.9	2.5
1999	2.5	2.5	2.5	0.5	2.5	2.5	-0.5	0.5	-0.5	0.5	-1.5	-2.5	-0.5	-2.5	287.2	2.5
2000	2.5	2.5	2.5	1.5	2.5	2.5	-0.5	0.5	-0.5	0.5	-1.5	-2.5	-0.5	-1.5	138.7	2.5
2001	-1.5	1.5	0.5	1.5	2.5	2.5	-0.5	0.5	-0.5	0.5	-1.5	-2.5	-0.5	-1.5	132.97	2.5
2002	-2.5	1.5	1.5	1.5	2.5	2.5	-0.5	0.5	-0.5	0.5	-1.5	-2.5	-0.5	-1.5	140.9	2.5
2003	-1.5	-1.5	0.5	1.5	-2.5	-2.5	-0.5	-0.5	-1.5	0.5	-1.5	-2.5	-0.5	-0.5	27.78	-1.5
2004	-1.5	-0.5	-0.5	0.5	-2.5	-2.5	-0.5	-0.5	-1.5	0.5	-1.5	-2.5	-0.5	-0.5	36.4	-1.5
2005	-0.5	-0.5	0.5	0.5	-2.5	-2.5	-0.5	-0.5	-1.5	-0.5	-1.5	-2.5	-0.5	-0.5	5.7	-1.5
2006	-0.5	-1.5	0.5	-0.5	-2.5	-2.5	-0.5	-0.5	-1.5	-0.5	-1.5	-2.5	-0.5	-0.5	0	-1.5
2007	1.5	0.5	2.5	-0.5	2.5	0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-2.5	-0.5	-0.5	45.1	-0.5
2008	1.5	0.5	-0.5	0.5	2.5	0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.5	-0.5	-0.5	224.7	-0.5
2009	-0.5	-0.5	-1.5	0.5	-1.5	-0.5	-1.5	-1.5	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5	24.6	-1.5
2010	0.5	-0.5	-2.5	1.5	-2.5	-0.5	-1.5	-1.5	-1.5	-0.5	-1.5	-1.5	-0.5	-0.5	3.5	-1.5
2011	0.5	0.5	-2.5	1.5	-2.5	-0.5	-1.5	-1.5	-1.5	-0.5	-1.5	-1.5	-0.5	-0.5	0.9	-1.5
2012	-0.5	-0.5	-2.5	1.5	-2.5	-0.5	-1.5	-1.5	-1.5	-0.5	-1.5	-1.5	-0.5	0.5	0	-1.5
2013	-1.5	-0.5	-1.5	-1.5	-2.5	-1.5	-1.5	-1.5	-1.5	-0.5	-1.5	-0.5	-1.5	0.5	0	-1.5
2014	-1.5	-0.5	-1.5	-1.5	-2.5	-1.5	-2.5	-2.5	-1.5	-1.5	-1.5	-0.5	-1.5	0.5	0	-1.5
2015	-0.5	0.5	-1.5	-1.5	-2.5	-2.5	-2.5	-2.5	-1.5	-1.5	-1.5	-0.5	-1.5	1.5	0	-1.5
2016	-0.5	-2.5	-2.5	-1.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-1.5	-0.5	-1.5	1.5	0	-2.5
2017	-2.5	-2.5	-1.5	-1.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-1.5	-0.5	-2.5	1.5	0.9	-2.5
2017	1.5	1.5	-2.5	-2.5	-2.5	-1.5	-1.5	-1.5	-1.5	-0.5	2.5	1.5	-2.5	1.5	0	-1.5

II. Methods

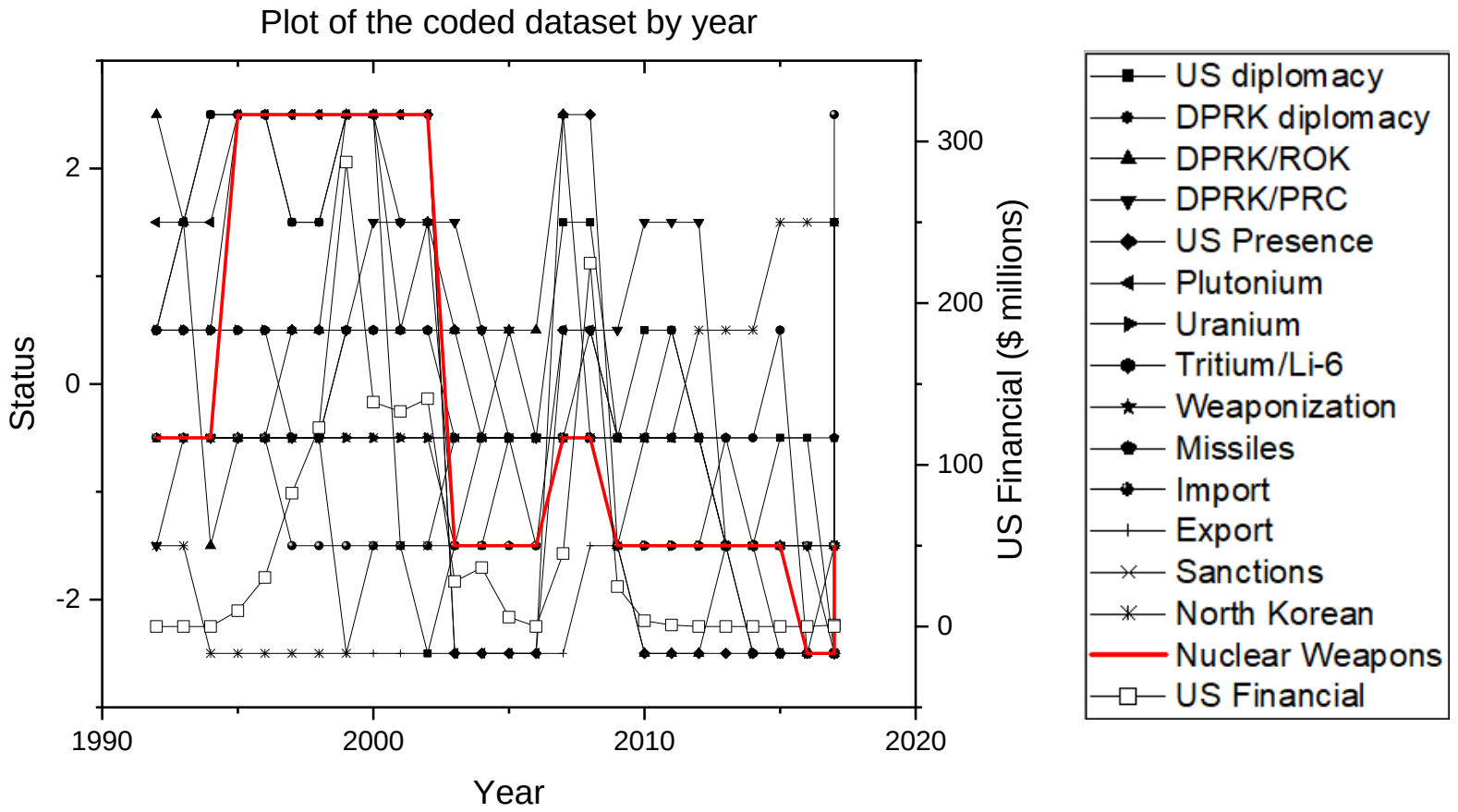
3. Multiple Linear Regression Analysis

Assumption: 15 x-variables independently linearly related with nuclear weapon level

Y – axis: Nuclear weapon (fissile material production, weaponization, nuclear test)

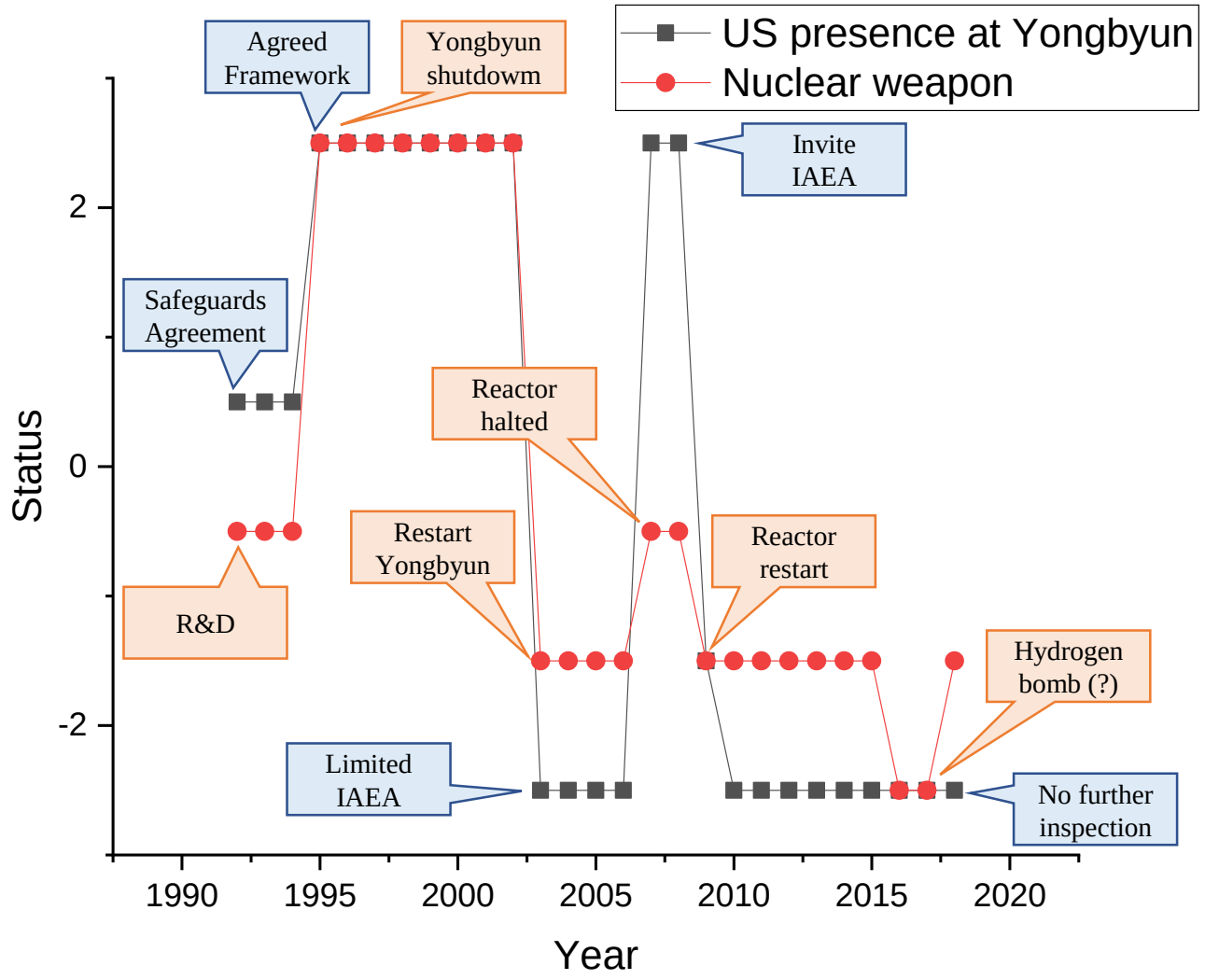
X – axis: 15 parameters

① US diplomacy
② DPRK diplomacy
③ DPRK/ROK relations
④ DPRK/PRC relations
⑤ US Presence at Yongbyun
⑥ Plutonium
⑦ Uranium enrichment
⑧ Tritium/Li-6
⑨ Weaponization
⑩ Missiles
⑪ Import
⑫ Export
⑬ Sanctions
⑭ DPRK Economy
⑮ US financial aid



III. Results

Independent variables	Coefficient	P-value
US Diplomacy	-0.085299508	0.639267501
DPRK Diplomacy	0.587146698	0.091784437
DPRK/ROK Relations	-0.012725761	0.951402357
DPRK/PRC Relations	-0.138530311	0.675922374
US Presence at Yongbyon	0.727048678	0.017344721
Plutonium	-0.046412323	0.88181235
Uranium Enrichment	-1.034775	0.169775308
Tritium/Li-6	1.167904279	0.146303088
Weaponization	-1.834325039	0.139923888
Missiles (Summary)	0.72214917	0.19085487
Import	-0.434221236	0.257444912
Export	0.310737667	0.516329518
Sanctions	0.318424866	0.719556377
North Korean Economy	-0.019219587	0.954682661
US Financial Aid (Millions)	-0.003111141	0.384854975



IV. Discussions

1. Inspection is a key factor

① The only independent variable showing p-value below 0.05 is “US(or IAEA) presence at Yongbyun”.

② Enhanced inspection from IAEA or US officials can deter DPRK nuclearization

Removing secrecy of uranium enrichment capacity & weapon grade Pu stockpiles

③ Other than on-site inspection, remote monitoring is also preferable.

For example:
Satellite imagery monitoring
Nuclear archaeology

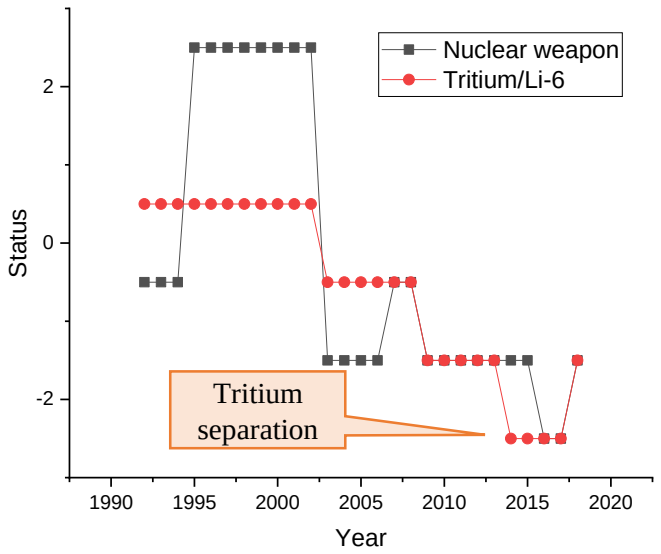
IV. Discussions

2. Technical capability is more (linearly) related than political situation

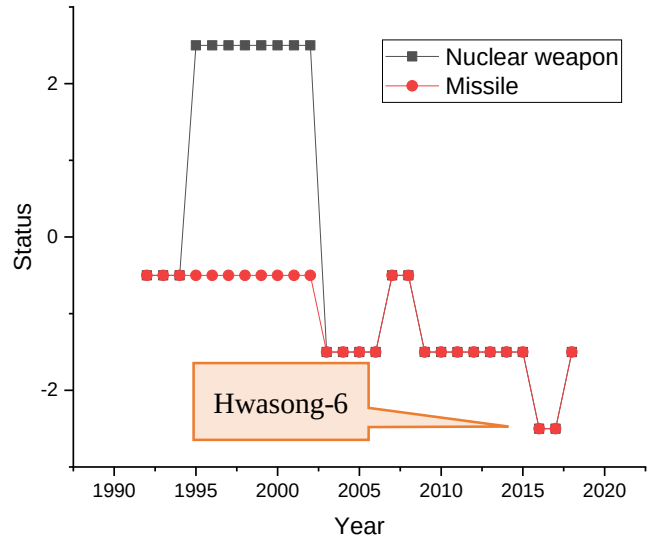
① p-value > 0.5: US diplomacy, DPRK-ROK, DPRK-PRC relations, exports, sanctions, domestic economy;
p-value < 0.2: uranium enrichment, tritium/Li-6, weaponization, missiles

c.f. (exception) p-value of "DPRK diplomacy": 0.092

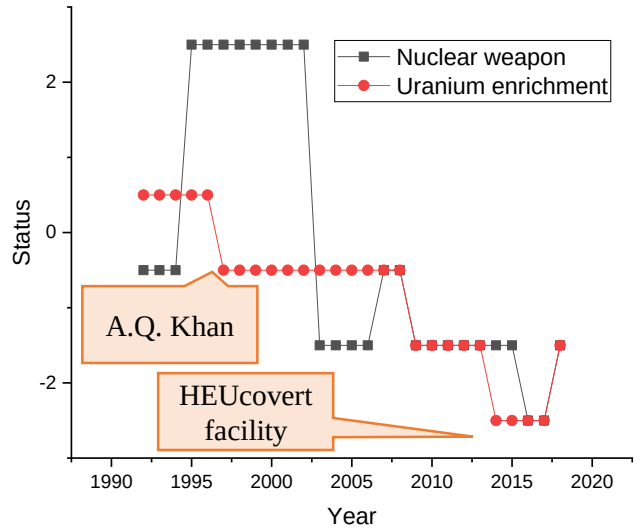
Tritium/Li-6
Coef. +1.168, p-val. 0.146



Missile
Coef. +0.722, p-val. 0.191



Uranium enrichment
Coef. -1.035, p-val. 0.170



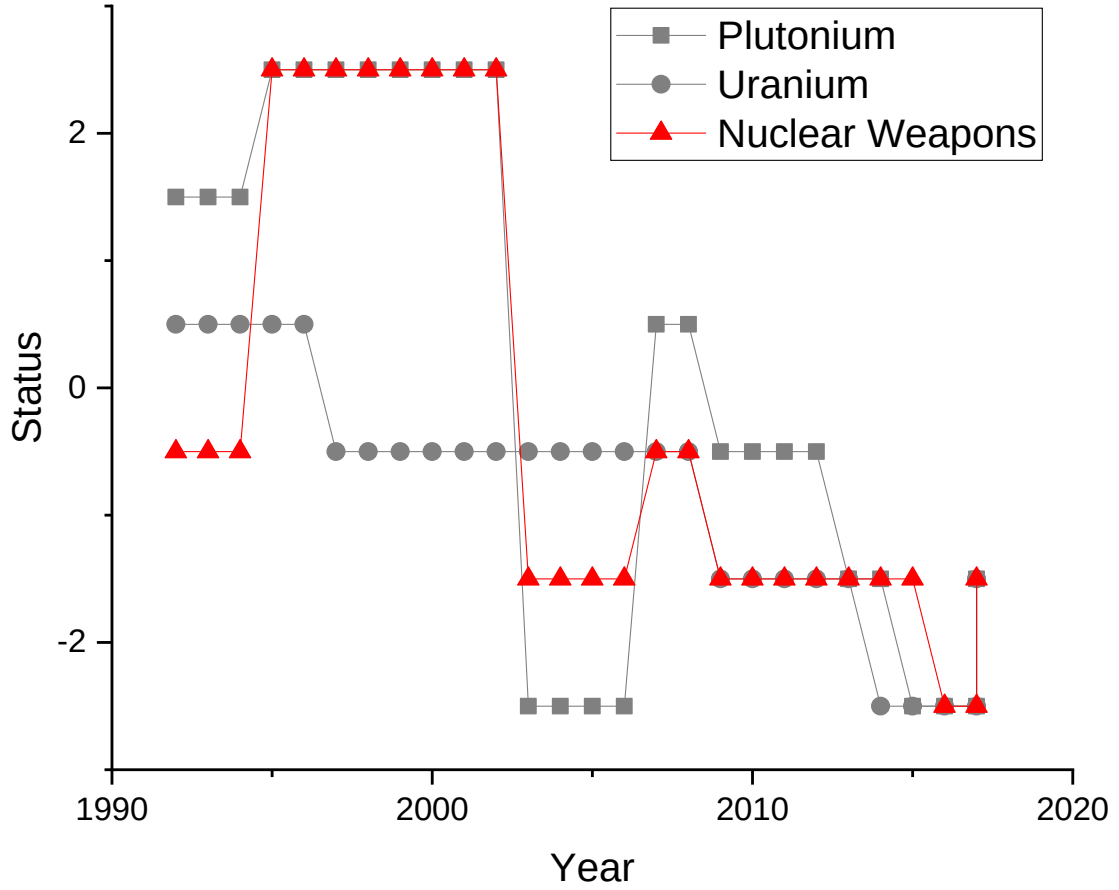
IV. Discussions

3. Uranium enrichment v.s. Plutonium extraction

① p-value of "Uranium enrichment" : 0.170;
p-value of "Plutonium" : 0.882

> "North Korea may have shifted the emphasis of its program to uranium enrichment and uranium-based weapons…The situation with regard to uranium enrichment is more difficult (Glaser and Mian, 2018)."

② It implies study on North Korea's uranium enrichment capabilities should be prior to plutonium technologies



V. Conclusion

1. Factors influencing DPRK's nuclearization

① Multiple linear regression analysis using dataset of DPRK nuclearization history
② Enhanced inspection from IAEA or US officials should be resumed
③ Tracking of its technical capability (e.g. uranium enrichment) is important

2. Possible scenario considering nuclear latency

① Transformation of DPRK into nuclear latent state by civilian nuclear power project
② Enhanced monitoring and inspection through return to international nonproliferation regime
③ Transaction must be come after disablement of nuclear arsenals (return of denuclearization)

3. Required further study

① Sophisticated statistical analysis to guarantee independency of (assumed) independent variables
② Quantification of the given dataset
③ Further discussion in the framework of nuclear latency

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