

7th World KLEMS Conference

Oct. 12, 2022

Manchester, UK

North Korea's Economic Growth Revisited with New Capital Estimates

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I. Introduction

- ◆ To analyze the existing growth process of a country and to present a realistic plan to enable sustainable growth of the country, **information about core components**, such as labour, capital, technology and institution etc., **need to be provided sufficiently**.
- ◆ However, it is **difficult to obtain information in North Korea** compared to other countries, and particularly **estimation of capital stock is further difficult task in North Korea** as many countries face a lot of difficulties in its estimation.
 - It is known that North Korean authorities **do not provide official data** related to them, and even if they do that, the data tends to be **only fragmented or exaggerated** rather than actual situations.
 - The estimation can be **connected to the process of reproducing and reinterpreting its macro statistics**.
 - ✓ For example, reconstruction of North Korea's economic growth and trade data, obtaining fixed investment and computing appropriate deflators are related tasks.
- ◆ Representative previous studies are **Jo(1993) and Kim(2002)**, but these have **limitation to accumulate long-term series with consistent methodology** or have a **critical error in calculation**.
 - Most of studies that estimates North Korea's capital stock before 1990 use North Korean budget data to estimate fixed investment, but the related information for recent years is not available any more.

I. Introduction

Differentiated from prior studies

- 1) We estimated North Korea's capital stock by dividing into **construction assets** and **facilities assets**.
 - Previous studies estimated only capital stock as a whole.
 - Now we could figure out **which assets were heavily invested in North Korea by period**.
 - 2) **Calculation errors of capital stock estimation** in prior studies were **corrected**.
 - Nominal investment → Real investment by a deflator → Real capital stock by PIM(Perpetual Inventory Method) → Nominal capital stock by reflation through deflator.
 - Kim(2002): Nominal investment → Nominal capital stock by PIM → Real capital stock by a deflator
 - 3) **Several parameters necessary for estimating capital stock** such as initial capital stock or depreciation rate of each asset **were proposed**, so it **can be used as a reference material** in conducting similar research in the field later.
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- We aim to **estimate North Korea's capital stock** by decomposing it into **construction assets** and **facilities assets**.
 - The estimates cover from **1955 to 2018**, so we'll **revisit North Korea's economic growth with new capital estimates**.



II. Methodology

◆ Perpetual Inventory Method (PIM)

- It is calculated by **subtracting the depreciation** incurred during time t **from the value of adding capital stock at the end of previous time $t-1$ to the investment** of time t .

$$K_t^E = (1 - \delta) \times K_{t-1}^E + I_t - \delta/2 \times I_t \quad \dots\dots\dots (1)$$

◆ Depreciation rate (δ) by asset

- It was calculated by the declining balance rate (DBRs) method
- Indirectly compute the depreciation rate : $\delta = DBD/T$ (where T is asset's average life)
 - ✓ DBR: how many times the value of reciprocal of life (1/T) decreases.
 - ✓ Average depreciation rate for both assets altogether between 1956 to 2018 was 4.8% (5%, Kim(2002))

◆ Initial capital stock (K_0)

- Capital stock estimation for South Korea is applied: Ratio of capital stock to GDP
 - ✓ Large-scale losses due to Korean War might have been restored to a considerable level in 1955.
 - ✓ GNP per capita in South Korea(\$65) and North Korea (\$66) almost same in 1955 (Statistics Korea, 1998).

| | | Construction Assets | Facilities Assets |
|--|-------------------------------|---------------------|-------------------|
| Depreciation rate(δ) | Service life (T) | 40 | 15 |
| | Declining balance rate (DBR) | 1.32 | 2.02 |
| | Depreciation rate(δ) | 3.30% | 13.47% |
| Initial Stock(K_0)/GDP Ratio as of the end of 1955 | | 120% | 30% |

II. Methodology

◆ Fixed Investment Series (I_t)

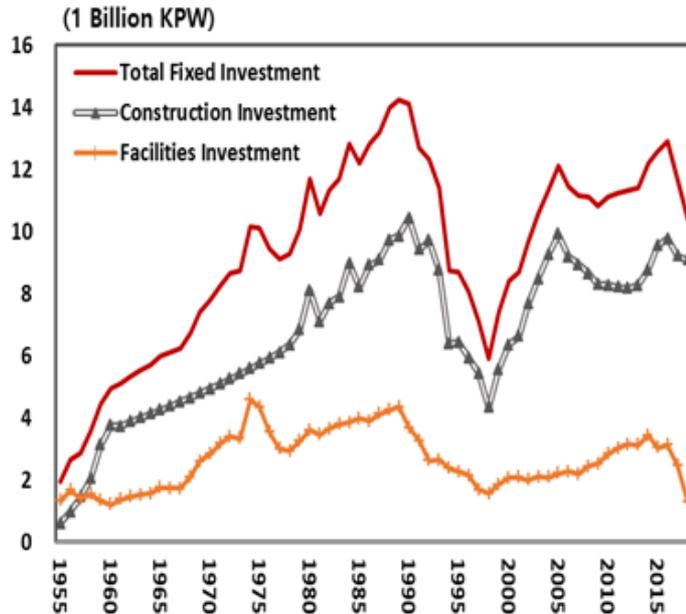
- 1) As a base year, construction investment and facilities investment are first estimated for 1990.
- 2) Real investment for each asset is derived by applying annual growth rate of each investment.

| | Construction and Facilities Investment | Construction Investment | Facilities Investment |
|---------------------|--|--|---|
| 1955-1989 | Construction investment + facilities investment | Retrospective estimation linked to growth rate of cement production | <ul style="list-style-type: none"> • Real net capital goods import is separately computed each year • Domestic capital goods production before 1990 is linked to growth rate of GDP in heavy and chemical industry |
| 1990 (Base year) | Assume 50% of expenditure on the people's economy plus military expenditures in budget data * Method adopted by Kim(2002) | Value-added of the construction industry in 1990 / 0.5 (= assumed value-added to gross output ratio) | <ul style="list-style-type: none"> • Facilities investment is derived from construction and facilities investment minus construction investment • Domestic capital goods investment is computed from facilities investment in 1990 minus net capital goods import |
| 1991-2018 | Construction investment + facilities investment | Construction investment after 1990 is linked to growth rate of value-added in construction industry | <ul style="list-style-type: none"> • Real net capital goods import is separately computed each year • Domestic capital goods production after 1990 is linked to growth rate of value-added in the heavy and chemical industry |



III. Results: Fixed Investment

Real Fixed Investment by Asset (at 1990 price)



- ◆ It has **continued to increase since 1955**, but after **hitting KPW 14.1 billion in 1990**, it decreased sharply, reaching **a low of KPW 5.6 billion in 1998**.
- ◆ **In 2000s**, North Korea's investment in fixed assets **increased again**, reaching **KPW 12.6 billion in 2016**, which was **similar to the level in mid-1980s**.
- ◆ However, **since 2017** it has **decreased due to sanctions** against North Korea, and it **stood at KPW 10.4 billion as of 2018**.

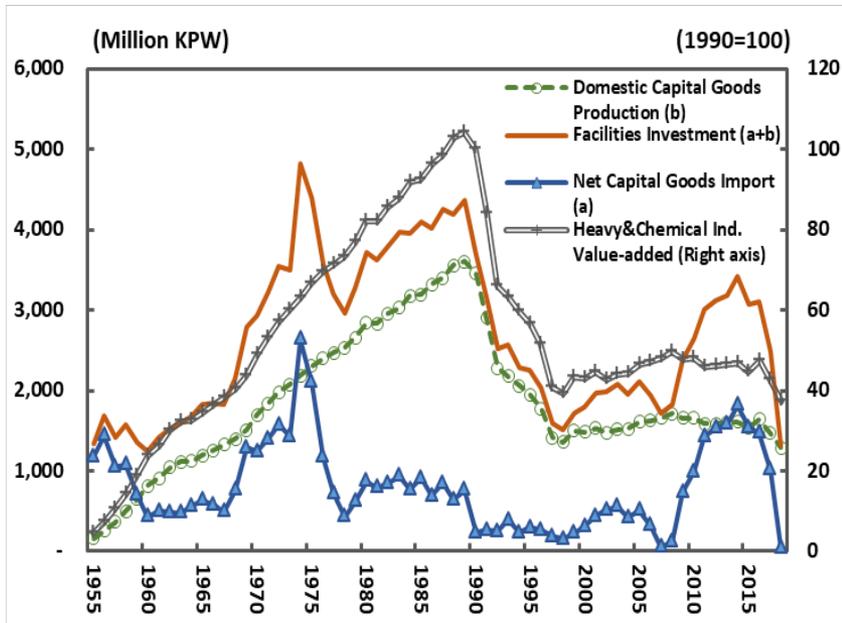
<By Asset>

- ◆ Both assets increased from 1955 to the late 1980s, but decreased rapidly until the late 1990s. → Since 2000s both investment increased steadily until 2016.
- ◆ **Trend** of both investment are **in line with North Korea history**.
 - **Construction investments** before 1990: construction of large public buildings was actively carried out **to celebrate 70th birthday of Kim il-sung**(April 15, 1982) and to prepare **the 13th World Festival of Youth and Students in July 1989**.



III. Results: Fixed Investment

Facilities Investment in detail (in real term)

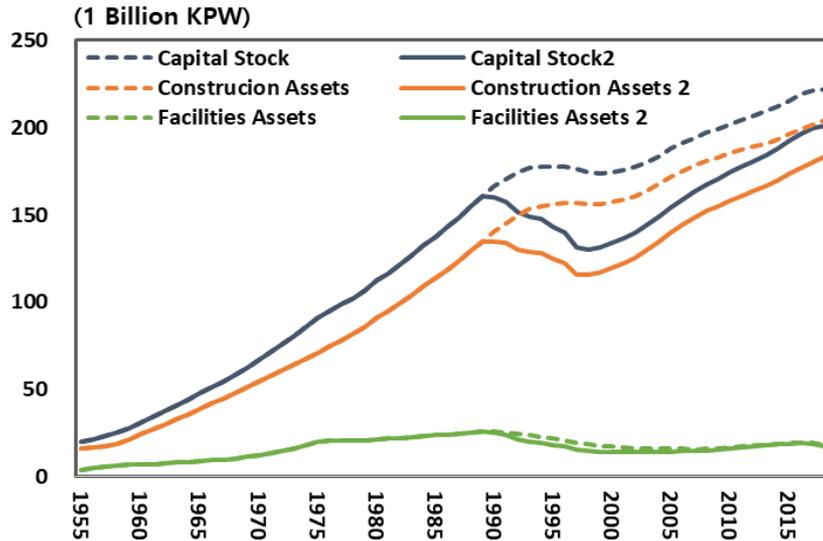


- ◆ Facilities investment is divided into overseas import and domestic production.
- ◆ It shows a close relationship with changes in North Korea's external trade environment and growth in production of heavy & chemical industry.

- ◆ Imports of capital goods increased through trade with Western developed countries such as West Germany and France in the early-1970s, but after 1975, trade sharply decreased due to overdue trade payments.
- ◆ Since 2010, the import of capital goods such as mining facilities and transportation vehicles increased significantly due to the rapid increase in North Korea's mineral exports, but since 2017 it decreased significantly due to restrictions on capital goods import caused by sanctions against NK.
- ◆ Meanwhile, after the Korean War, NK adopted a growth strategy based on the heavy industry-priority development → impact on the increase in domestic production of NK facilities investments until 1980s.

III. Results: Capital Stock

Capital Stock of NK(at 1990 price)

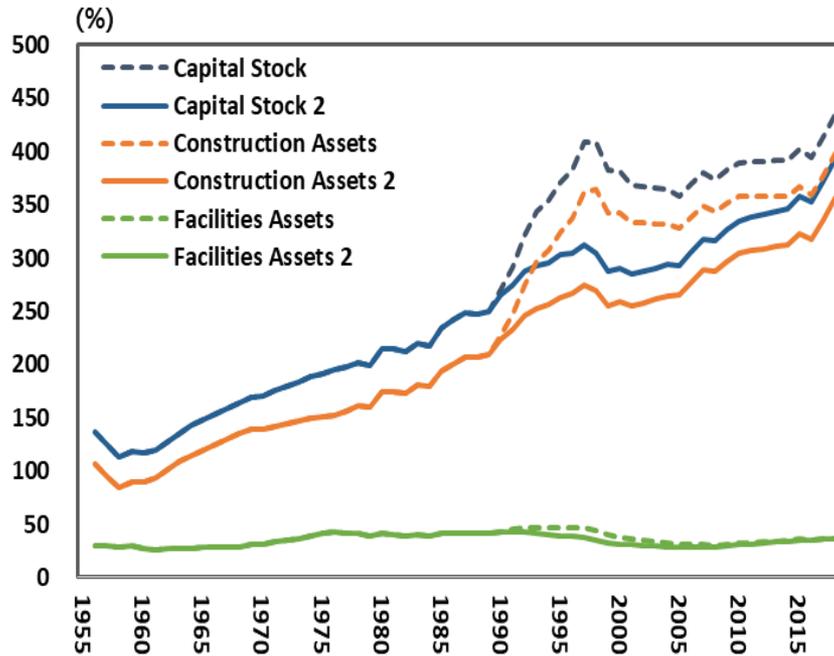


- ◆ **Series 2** was estimated in consideration of the possibility that **capital losses** may have **occurred rapidly** at a time when **economic difficulties** were **severe in the 1990s**.
 - Many workers artificially disposed of machinery and parts, so the factories were greatly damaged in NK during the period of Arduous March.
 - Assumption: capital stocks declined by the same decrease rate of GDP during the period of 1990~1998.

- ◆ NK's capital stock **peaked at KPW 162 billion in 1989**, and dropped in the 1990s.
- ◆ **After 2000**, it **began to rebound**, recording KPW 162.4 billion **in 2007**, **recovering to the level in 1989**, and as of 2018 it was estimated at KPW 200.2 billion.
 - **As of 2018**, **construction asset** was **higher than the level of 1989**, while **facilities assets** were **still below** the level of 1989.
- ◆ **Composition ratio** of **construction and facilities asset** gradually widened from **8:2 in the 1980s** and the early 1990s, but it shows **9:1 since 2000s**.
 - Considering that **South Korea's facilities asset accounted for 32% of fixed assets between 1970 and 1990**, **North Korea** did **not** seem to have **invested enough in new facilities assets** for the purpose of economic recovery and industrial reconstruction.

III. Results: Capital Stock

Capital Stock to GDP Ratio



- ◆ **NK's capital stock**(based on Series 2) was estimated to be **3.9 times GDP** as of 2018.
 - This scale of capital is mainly observed in developed countries; it can be understood because the NK's GDP did not grow enough rapidly. → **Low productivity** and **inefficiency** of the North Korean economy.

< Ratio to GDP by asset as of 2018 >

- ◆ **Construction** assets/GDP = **358%** (SK, 81%; 1971-75)
- ◆ **Facilities** assets/GDP = **33%** (SK, 34%; 1971-75)
- ◆ Ratio of **facilities assets** to GDP in North Korea in 2018 is **similar with South Korea** for the period from 1971~1975, **but** ratio of **construction assets** to GDP between North Korea and South Korea shows a **very large difference**.
- **Imbalance** between North Korea's **facilities assets** and **construction assets** is **severe**.
 - It is associated with problems such as **aging of the electrical grid and of machinery facilities**, and it is expected to **worsen productivity** and **increase inefficiency of investment**.



III. Results: Capital Stock – Robustness Check

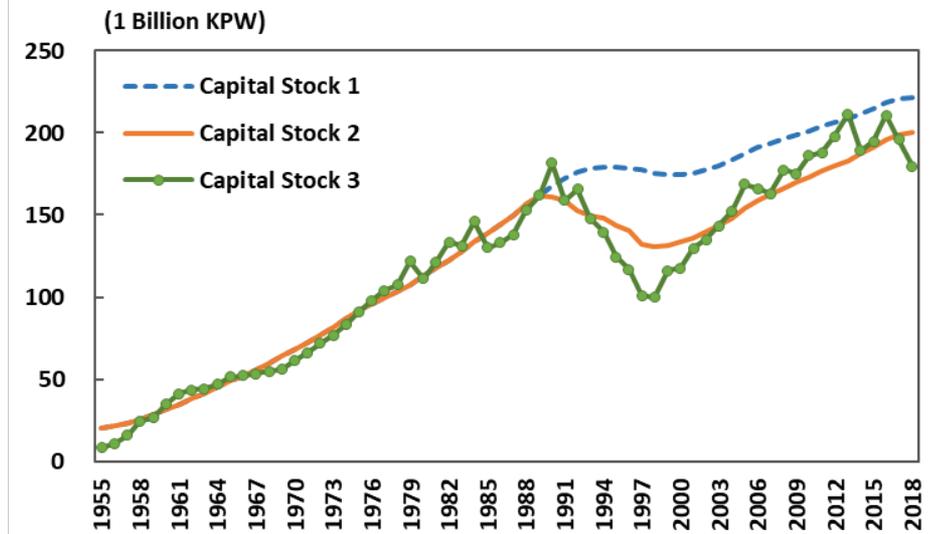
Estimation NK's labour productivity

| | Dependent variables: Labour productivity |
|-------------------|---|
| Capital intensity | 0.41 (5.91)*** |
| Trend | -0.01 (-7.17)*** |
| Prior to 1989 = 1 | 0.18 (3.79)*** |
| Constant term | 0.91 (8.17)*** |
| Observations | 61 |
| R2 | 0.97 |
| F-statistics | 15.505 |

Note: assume the Cobb-Douglas function

- ◆ To confirm the robustness of our estimates: (1) estimating the production function of North Korea, (2) inserting the labour force and real GDP data into the function and then computing capital stock in reverse → **Capital Stock 3**
- Capital elasticity of output was 0.41 at the significance level of 1%
- **Trend**, which means **technological progress and institutional efficiency**, was **estimated to be negative**
- **Capital Stock 3** shows a trend **generally similar to Capital Stock 2**.

Estimation of capital stock using the coefficient derived from production function estimation

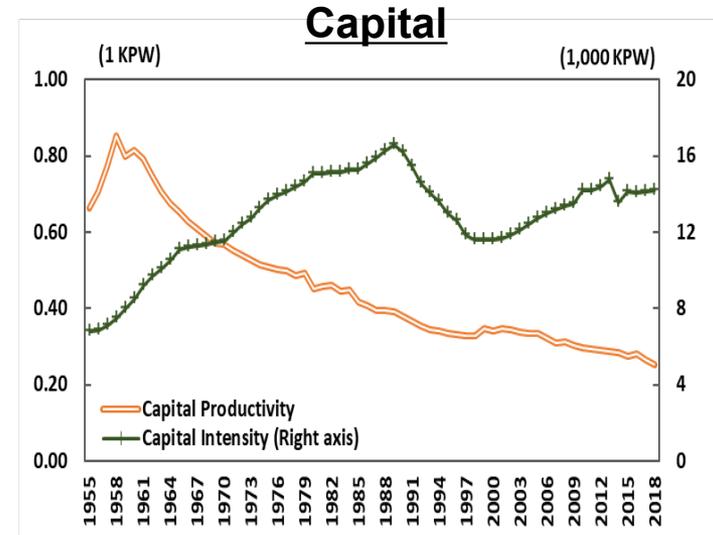
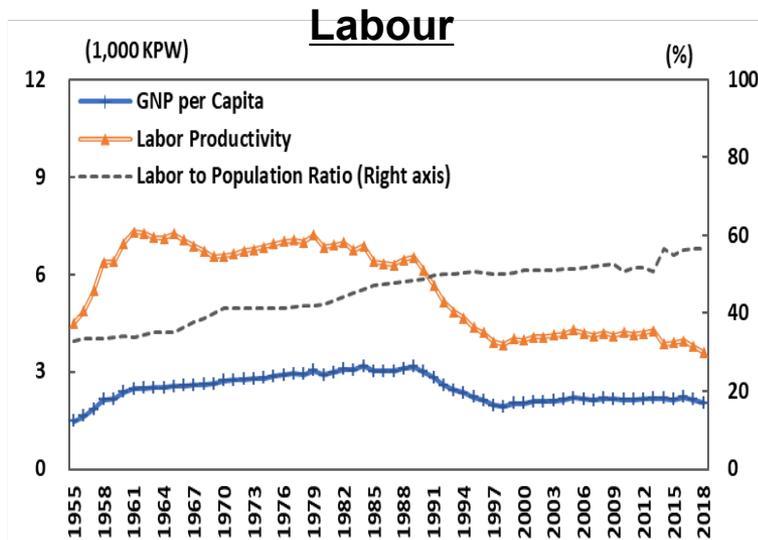


Note: Capital Stock 1 and Capital Stock 2 was estimated by the PIM, and Capital Stock 3 is inversely computed by the production function.



III. Results: Growth Accounting

(1) Quantitative and Qualitative Growth of Labour and Capital



- ◆ **Quantitative growth** : ratio of labour force to population and capital intensity
- ◆ **Qualitative growth**: labour and capital productivity.
- ◆ **Quantitative labour** input continued to **increase**, but **qualitative growth** was **not accompanied**.
- ◆ **Capital intensity** continued to **rise until the 1980s**, but reversed to **decrease in the 1990s**. → **Since 2000**, the capital intensity **rebounded**.
- ◆ **Capital productivity** increased significantly **in the late 1950s**, but has continued to **decline since the 1960s**.
 - Although investment in fixed assets increased in the 1970s and 1980s and GDP also showed growth, the continued decline in capital productivity suggests a **problem in terms of capital utilization**.

III. Results: Growth Accounting

(2) Growth Accounting

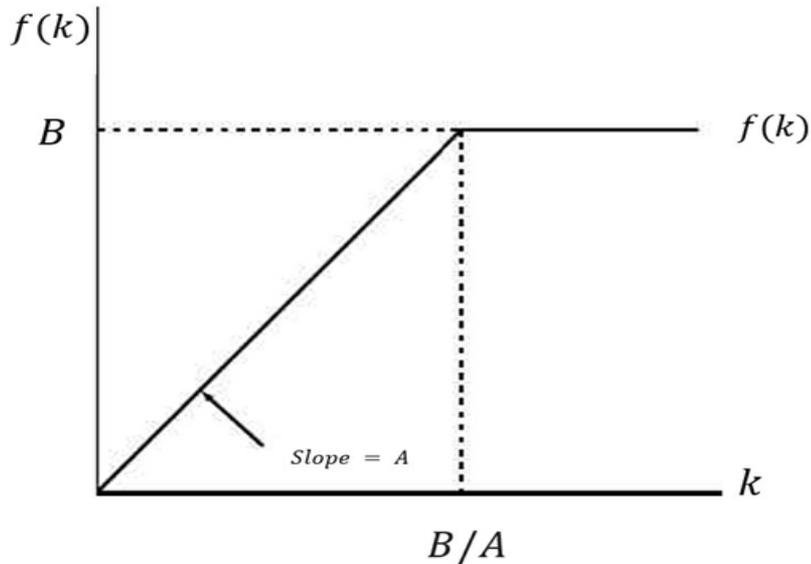
(Average annual growth rate, %, %p)

| | GDP growth Rate | Contribution to the increase rate of labour input | Contribution to the increase rate of capital input | Total factor productivity growth rate |
|-----------|-----------------|---|--|---------------------------------------|
| 1956~1969 | 7.0 | 2.6 | 3.4 | 1.1 |
| 1970~1989 | 2.8 | 1.7 | 1.9 | -0.8 |
| 1990~1999 | -3.3 | 0.9 | -0.9 | -3.3 |
| 2000~2009 | 1.3 | 0.6 | 1.0 | -0.4 |
| 2010~2018 | -0.2 | 0.8 | 0.7 | -1.7 |
| ('10~'16) | 0.9 | 0.9 | 0.8 | -0.8 |
| ('17~'18) | -3.9 | 0.4 | 0.5 | -4.8 |

- ◆ (1956~1969) GDP growth rate was 7.0%, contribution of NK labour input and capital input growth were 2.6% points and 3.4% points, respectively. → **High economic growth rate** in NK at that time was **due to the enormous capital investment**.
- ◆ (1970s~1980s) Economic growth rate plunged to 4.2%points; both input growth rates fell significantly, and it is noted that **total factor productivity turned negative**. → **Inefficiency of socialist economic system** had **already intensified**.
- ◆ (2000~2016) Contribution of input growth was positive, contributing to positive GDP growth, but **factor productivity growth showed negative sign**. → **Led to a chronic low growth state**.
- ◆ (Since 2017) **Contribution of both input growth has fallen by half**; growth rate of **total factor productivity** has reached a low of **-4.8%**. **Annual economic growth rate** was **-3.9%**.
- ◆ NK achieve **input-led growth** based on **mobilization of labour** and **increased capital input in the 1950s ~ 1960s**, but **since then, total factor productivity continued to decrease**. → **Low level of total factor productivity** that lasted for a long time was a **major cause of North Korean economic downturn** (Kim et al., 2007).
- ◆ It is not much different from the situation in which the **former socialist countries experienced deep inefficiency** and **did not**

III. Results: Theoretical Explanation

Leontief Production Function on per Capita Capital

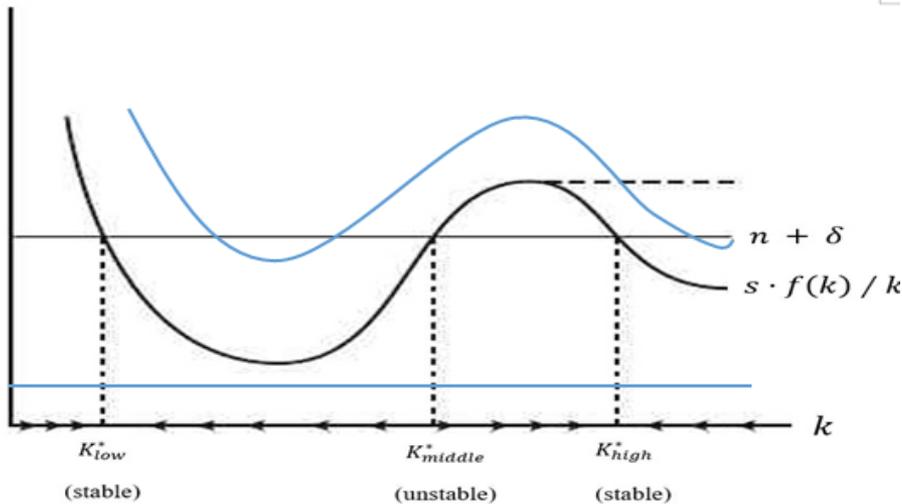


- ◆ Pyo(2013) proposed **aggregated Leontief** or fixed coefficient production function rather than Cobb-Douglas as a **more appropriate production function** for emerging economies and transition economies.
- **In the case of NK**, most production functions are for public goods, and **there is little possibility of substitution between capital and labour**.
- ◆ The assumption that there is no substitution between capital and labour assumed in the Leontief production function **led unintended consequences** of a **continuous increase in labour input or idle capital** (Barro and Sala-i-Martin, 1995).
- **In the case of North Korea**, it can be said that **idle capital** continues to **increase during the period of Arduous March in the mid-1990s**.



III. Results: Theoretical Explanation

The Poverty Trap



Note: n refers to population growth rate, δ refers to depreciation rate, and $n+\delta$ indicates minimum requirement growth rate.

Source: Barro and Sala-i-Martin (1995, p.50)

- In order to escape from the poverty trap, only a large amount of sufficient capital support from outside, such as support from World Bank or ADB, etc., can increase per capita capital(k) to a higher level than $k^{*middle}$ or endogenous steady-state growth path.
- As see growth accounting model, total factor productivity in NK continued to show negative growth rate for a long time, which is in line with the possibility of North Korea going back to the poverty trap, emphasizing once again the need for North Korea to accumulate large-scale capital (aid or loan) and acquire technology from developed countries through opening and reform.

- ◆ Where K^* is low, it shows a decreasing return to scale; focus on industries such as agriculture and mining, as in the case of North Korea in the 1950s ~ 1960s.
- ◆ As the economy develops, it focuses on manufacturing and service industries and may have an increasing return to scale, but in the case of NK, it fails to take enough profits from labour division and learning effects.
- ◆ In the end, they experienced a decreasing return to scale again, staying in the poverty trap.



IV. Summary and Implication

- ◆ This study estimates the long-term capital stock in North Korea from 1955 to 2018 and explain North Korea's economic growth with new capital estimates.

Contributions

- I. **First**, we **estimates** not only **total amount of capital stock** but also those **by assets** (construction asset and facilities asset).
- II. **Second**, through **robustness check** of **backward estimation of capital stock** using the coefficient derived from production function estimation, we could **enhance the reliability of our estimates**.
- III. **Third**, the **growth path of the North Korean economy**, which was **explained by the estimates**, was **consistently** shown through the **theoretical model**.
- IV. **Lastly**, it could help to **give a reference for estimating capital stocks** in **countries with insufficient macroeconomic data**.

Implications

- As NK's growth conditions have deteriorated significantly due to the embargo on capital goods, it is required to **improve its system** that **promotes productivity, efficiency and creativity** through **innovation in the ownership structure** and **management of farms and enterprises**.
- **More favorable foreign relations** and an **active opening policy** are also **necessary to attract foreign investment and technology**, which is **essential for human and physical capital accumulation** and the **resulting economic growth**.



Thank You

