ESTIMATING DEMAND FOR FLOOD CONTROL INFRASTRUCTURE

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1. Introduction:
Large capital stock for disaster-related

Disaster Related 11%
Yet its demand estimate not available

- Many estimates for economic infrastructure investment only.
  - ADB(2017), *Meeting Asia’s Infrastructure Needs*
  - Mckinsey Global Institute(2013), *Infrastructure Productivity*

- No studies for demand estimate on disaster related and social infrastructure, despite its large magnitude.
No established methodology for estimate

- Stylized model for economic infrastructure demand is **not applicable** for disaster-related.

  ✓ Economic infrastructure demand = (1) household consumption + (2) production sector

  (1) Household demand = f (Y, qI)

  (2) Production sector demand = f (Y, qI, Yagr, Yind, A) /Cob-Douglas production function

  *Y: income, qI: infrastructure service price, Yagr: Agriculture per GDP, Yind: Industry per GDP, A: technology

\[
I_{i,t} = \alpha_0 + \alpha_1 I_{i,t-1} + \alpha_2 y_{i,t} + \alpha_3 A_{i,t} + \alpha_4 M_{i,t} + \alpha_5 D_i + \alpha_6 D_t + \epsilon_{i,t}
\]

IJ (i, t) = demand for infrastructure stock of type j-th in country i-th at time t;
IJ(I, t-1) = the lagged value of the infrastructure stock,
y (i, t) = income per capita of country i-th;
A(i, t) = share of agriculture value added in GDP of country i-th;
M(i, t) = the share of manufacturing value added in GDP of country i-th;
D(i) = a country fixed effect,
D(t) = a time dummy;
e(i, t) = error term.
(Ref) Economic infrastructure demand is universally the simple increasing function development.

- Existing stock of Infrastructure
- New construction
- O&M and depreciation (equivalent with x % of total)

Demand of year 2015: 22.6 trillion USD for new and O&M (26 trillion USD, incl. climate changes)
Difficulty of estimate on disaster related

- Large differences of disaster risk by country due to its climate, geological and topographical conditions.
- Difficulty to identify the area to be invested by using macro estimate model.
- Difficulty to standardize the required target setting for disaster prevention.
- Difficulty to collect information on disaster damage and budget
Our approach for estimate

- Macro-model is not applicable. Bottom-up approach (aggregation of all projects) is not practical.
- Budget record must reflect differences of climate, geological and topographical conditions. The common historical trend may be identified by studying budget record.

JICA focuses on budget record.
2. Relationship between flood control investment & damage: from global experiences

Flood Control Budget/GDP(%)
Flood control investment depends on historical records of most severe disaster on national economy.

Investment % (of GDP)

Worst disaster damage (% of GDP)
3. Investment in Japan
(a) Damage mitigation by accumulating investment
   - Historically disasters were the investment trigger

(% of National Income)

- Damaged Osaka City
- Damaged throughout the country
- Typhoon Kathleen
  Damaged Tokyo Metropolitan Area
- Typhoon Isewan
  Left over 5,000 causalities in Nagoya Metropolitan Area

- Economic damage
- Flood control budget
- Budget increase


0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0

- 0.1-0.3%
FC investment could drastically decrease casualty due to disaster

Flood control budget
(100 million JPY, 1995 price)

Death toll (person)
(b) Flood control investment created asset value in risk areas, as the economic grew

- Benefit of Investment
  (Billion Yen, Price Adjusted to 1995)

- Flood Protection Investment
  (Billion Yen, Price Adjusted to 1995)

Tsukahara (2015)
Urbanization and economic growth brought damage density (damage/area) to rapidly increase.

- In 1965: 1.4 Million JPY/ Ha
- In 2005: X50
- In 2015: X20
(c) How can we use JPN’s experiences for global estimate?

As economy develop, investment increase
Investment start decreasing once stock accumulate
Infrastructure investment by MLIT
Replacement cost increase, new investment decrease
Estimate for flood control investment

Relationship between budget for flood control and (a) urban ratio (1893-2000) (b) per capita GDP (1875-2000)

- For urban ratio:
  \[ y = 407.58x - 8179.7 \]
  \[ R^2 = 0.7241 \]

- For GDP per capita:
  \[ y = 1.9054x - 1966.1 \]
  \[ R^2 = 0.9877 \]
Demand estimate of investment Multiple regression model

\[ I_t = \alpha_1 I_{t-1} + \alpha_2 A_t + \alpha_3 U_t + \alpha_4 G_t + \beta \]

**I**: investment, **A**: protected area, **U**: urbanization, **G**: Per cap GDP, **t**: year

- \( I_{t-1} \): previous year’s budget: scale of damage & inflexibility of budgeting
- **A**: protected area: As protected area increase, investment decrease
- **U**, & **G**: urbanization & per capita GDP: assets to be protected
<table>
<thead>
<tr>
<th>Variables</th>
<th>coefficients</th>
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<tbody>
<tr>
<td>Intercept</td>
<td>2107.754</td>
<td>2120.001</td>
<td>6643.074</td>
<td>1031.108***</td>
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<tr>
<td></td>
<td>(0.479)</td>
<td>(0.483)</td>
<td>(1.600)</td>
<td>(3.542)</td>
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<td>Previous yr</td>
<td>0.651569***</td>
<td>0.644085***</td>
<td>0.772967***</td>
<td>0.661148***</td>
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<tr>
<td>investment</td>
<td>(5.155)</td>
<td>(5.098)</td>
<td>(6.372)</td>
<td>(5.574)</td>
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<td>Protected area</td>
<td>-35.0033**</td>
<td>-33.6786**</td>
<td>—</td>
<td>-36.8883***</td>
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<tr>
<td></td>
<td>(-2.290)</td>
<td>(2.201)</td>
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<td>(-2.830)</td>
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<td>Urbanization</td>
<td>-20.8187</td>
<td>-22.9561</td>
<td>-118.554</td>
<td>—</td>
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<td></td>
<td>(-0.2453)</td>
<td>(-0.2709)</td>
<td>(-1.528)</td>
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<tr>
<td>GDP per capita</td>
<td>0.000486*</td>
<td>0.000489*</td>
<td>0.000399</td>
<td>0.000435***</td>
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<tr>
<td></td>
<td>(1.828)</td>
<td>(1.844)</td>
<td>(-1.528)</td>
<td>(2.608)</td>
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<td>Damage</td>
<td>—</td>
<td>0.009139</td>
<td>—</td>
<td>—</td>
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<tr>
<td></td>
<td></td>
<td>(1.065)</td>
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<tr>
<td>Adjusted R²</td>
<td>0.844254</td>
<td>0.844851</td>
<td>0.639535</td>
<td>0.848319</td>
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4. Philippines rapidly increasing investment after recent serious typhoons

Trends of flood damage, budget, and GDP per capita

- damage B PhP 2105 price
- Invest B PhP 2015 Price
- GDP per capita 1,000 PhP 2000 constant
Investment estimate on flood control in Philippines 2016-30
USD 32.3 – 61.4 billion (PhP 1.47-2.79 Tri.)
Urbanization, per capita GDP, & previous year budget as explanatory variables

\[ I_t = \alpha I_{t-1} + \beta U_t + \gamma G_t + \delta \]

\( I \): investment, \( U \): urban ratio, \( G \): Per cap GDP, \( t \): year

R² value: 0.909, adjusted R² value: 0.896.
Change of risk area in Davao
Asset value in risk areas increase because of urbanization & economic growth

2008
48.02km²
Risk Area 4.03km²

2015
72.46km²
Risk Area 10.26km²

Legend

Investment estimation on flood control in Philippines 2016-2030
USD 32.3 – 61.4 billion (PhP 1.47-2.79 Tri.)
Balance (benefit-cost) accumulation becomes positive in 2025

Economic Analysis
for estimation by regression model

Investment estimation
- with same pace of GDP growth
- Multiple regression model

Annual invest
Benefit
Accumulated Balance B-I
5. Tentative conclusion

- For some countries, JPN, UK, Netherlands, PHI, CHI, disasters were the trigger for investment

- Japanese experience shows,
  - Investment was fully paid off
  - securing flood control budget of central government needs political intervention: legislation, institution, commitment (long-term plan), budget sharing with local government

- Philippines is rapidly increasing investment for flood control, estimated from 0.45% in 2015 to 1.08% of GDP in 2030
Way forward

1. Collecting budget information of other flood prone countries: IND, IDN, BAN, CHI, VET, THI, CHI TAIPEI, Malaysia…..
2. Develop common regression model in Monsoon Asia, if possible
3. Estimate demand in all developing Asia
Thank you very much
ANNEX 1
HOW LONG DOES IT TAKE TO DOUBLE INVESTMENT?
Japan modernization era before WW2 increasing steadily in the late 19th Century

Investment 1995 price/ Ave (1875-80)
Japan modernization era before WW2

stagnated in the early 20th Century

Investment
1995 price/ Ave (1875-80)

Military expansion & War

Great Depression

Kanto EQ

Inflation

Russia War

China War

35yr

15yr

1yr

5yr

1880 1883 1886 1889 1892 1895 1898 1901 1904 1907 1910 1913 1916 1919 1922 1925 1928 1931 1934 1937 1940 1943
Correlation with damage and national income

Damage
(5yr moving ave / ave (1865-70) 1995 price )

Per capita national income
/1879 (1995 price)
After WW2, Constantly doubling until 1980


3yr 1yr 1yr 12yr 8yr 8yr

(fold)
Correlation with national income opposite correlation with damage

Per capita national income

Damage 5yr moving ave
Philippines: rapidly increasing recently
China: rapidly increasing recently
Indonesia

(fold)


10yr
Industrialized countries
UK & NL increasing budget some
ANNEX 2
INVEST/ REHABILITATION
HOW CHANGING
Japan: ratio of (flood control/rehabilitation) by increasing investment. Ratio is increasing = damage decreasing.

Flood control budget
Rehabilitation budget

Flood control = Rehabilitation
The Philippines: flood control/ rehabilitation
the ration is not increasing
= Still needs investment increase

Flood control budget
Rehabilitation budget
ANNEX 3
INVESTMENT TREND IN JAPAN
1896 flood triggered central government intervention

**Legislation**: river law enacted from local efforts to central government initiative

- Damage: 11.36% of national income
- Death toll 1250

Shinanogawa River, Source: MLIT
1910 floods: government commitment formulated long-term budget plan and special account

- Damage: 3.6% of national income
- 2500 people died
  - Saitama Pref,
not always secured budgets

- 1894-95: Sino-Japanese war
- 1904-05: Russo-Japanese war
- 1910s: inflation
- 1923: rehabilitation following the Great Kanto Earthquake
- 1929: the Great Depression
- 1930s: allocated major portion for military expansion

from 1946 until 1959

the country suffered from serious floods
Annual economic damage 1-10 % of National Income
Isewan Typhoon in 1959 killed 5,098, flooded 1.2 million houses in Nagoya
Mega disasters happened almost every year after WWII

- Mikawa Earthquake (2,306 people)
- Makurazaki Typhoon (3,756 people)
- Kathleen Typhoon (1,930 people)
- Fukui Earthquake (3,769 people)
- Nanki Torrential I
- Toyamaru Typhoon
- Ise
Budget share (%)
Flood control & Disaster rehabilitation / public works over 50%, recovery > prevention in the 1950s

Flood Control + Rehabilitation