

# Summary of Methodology for Estimating Stock of Infrastructure in Japan and Estimation Outcomes. (Measuring Infrastructure in Japan 2022)

## 1. Summary of methodology for estimation

### (1) Sectors to be estimated

The sectors covered in this estimation are the following 18 sectors where operators are public institutions in a narrow sense with the condition that continuous data is available.

Table 1 18 sectors in infrastructure to be estimated

Sector Number	Sector Name	Sector Number	Sector Name
1	Road	10-1	Cultural and educational facilities (school and academic facilities)
2	Port and Harbour	10-2	Cultural and educational facilities (social education facilities, social sports facilities, cultural facilities)
3	Aviation	11	Flood control
4-1	Railways (Railway Construction, Transport and Technology Agency)	12	Forest conservation
4-2	Railways (Underground)	13	Coast conservation
5	Public housing for rent	14-1	Primary sector (Agriculture)
6	Sewerage	14-2	Primary sector (Forestry)
7	Waste disposal	14-3	Primary sector (Fishing)
8	Water supply	15	Postal service
9	Public park	16	State forest
		17	Industrial water supply
		18	Government building

### (2) Types and definitions of stock

Gross capital stock, net capital stock, and productive capital stock in the 2015 calendar year have been estimated. The definitions of each type of stock are in Table 2.

Table 2 Definitions of each type of stock in estimation

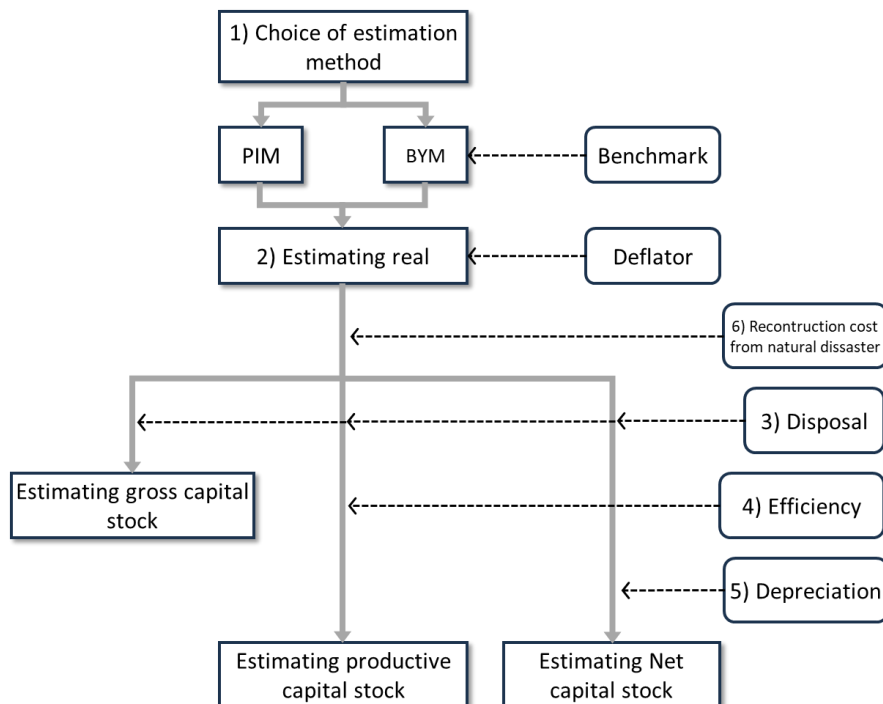
Gross capital stock	Asset endowment. Value of existing fixed assets assessed by their acquisition price (investment value).
Net capital stock	The value of the gross capital stock less depreciation (loss of value due to physical wear and tear, obsolescence, etc.) over the years of use.
Productive capital stock	The value of the gross capital stock less efficiency losses (reduction in capacity to produce services) over the years of use.

(3) Methodology for estimating national stocks

Estimation methods used in this estimation are worldwide mainstreaming Perpetual Inventory Method (hereinafter referred to as PIM) and Benchmark Year Method (hereinafter referred to as BYM), which are based on the cumulative investment and used in estimating capital stock in the System of National Accounts (hereinafter referred to as SNA).

The basic estimation process for both methods is as follows: first, the nominal investment is substantiated and accumulated, and then the gross capital stock is obtained by deducting the age-appropriate retirement amount from the accumulated amount. The net capital stock can then be obtained by deducting the age-related depreciation and the productive capital stock by deducting the efficiency losses. Figure 1 shows the flow of estimation and details.

Figure 1 Flow of stock estimation



1) Choice of estimation method

For sectors where data of long-term investment are available, PIM is used and otherwise, BYM.

Table 3 Estimation methods for each sector

Estimation method	Sector
PIM	Road, Port and Harbour, Railways (Railway Construction, Transport and Technology Agency), Railways (Underground), Primary sector (Agriculture, Forestry)
BYM	Aviation, Public housing for rent, Sewerage, Waste disposal, Water supply, Public park, Cultural and educational facilities (school and academic facilities), Cultural and educational facilities (social education facilities, social sports facilities, cultural facilities), Flood control, Forest conservation, Coast conservation, Primary sector (Fishing), Postal service, State forest, Industrial water supply, Government building

For the sectors that would be estimated by BYM, the gross capital stock value for 1953 or 1963 was converted to 2015 calendar year prices from the values in the data of the General Planning Department of the Economic Planning Agency (1968), which were used as the initial year stock.

Table 4 Initial fiscal year of sectors estimated by BYM

Initial FY	Sector
1953	Aviation, Public housing for rent, Waste disposal, Water supply, Cultural and educational facilities (school and academic facilities), Flood control, Forest conservation, Coast conservation, Primary sector (Fishing), Postal service, State forest, Government building
1963	Sewerage, Public park, Cultural and educational facilities (social education facilities, social sports facilities, cultural facilities), Industrial water supply

Estimation equations were used for the PIM and BYM respectively.

(1) PIM

$$K_t = K_{t-1} + I_t - R_t = \sum_{i=1}^t I_i - \sum_{i=1}^t R_i$$

$K$  : Capital Stock

$I$  : New construction and improvement cost

$R$  : Values including disposal, efficiency decline and depreciation

$t$  : Relevant fiscal year

## (2) BYM

$$K_t = K_{t-1} + I_t - R_t = K_b + \sum_{i=b+1}^t I_i - \sum_{i=b+1}^t R_i$$

$K$  : Capital stock

$I$  : New construction and improvement cost

$R$  : Values including disposal, efficiency decline and depreciation

$t$  : Relevant fiscal year

$b$  : Initial fiscal year

## 2) Real investment

Nominal investment for accumulation is derived from the data collected by the Cabinet Office of Japan in accordance with the concept of the Government Capital Investment in SNA.

Nominal investment for estimation was transformed to real investment in year 2015 standard by the deflator adjustment system.

## 3) Disposal

In this estimation, the stock is to be disposed in accordance with the Weibull distribution. The probability distribution function of the Weibull distribution is described as follows.

$$F_T = \frac{m}{\eta} \left( \frac{T}{\eta} \right)^{m-1} e^{-\left( \frac{T}{\eta} \right)^m}$$

$F_T$  : Probability of stock disposal at age  $T$

$m$  : shape parameter

$\eta$  : scale parameter

The shape parameters are set to be between 1.69 and 4.00 for each sector based on the literature review. (The concrete values of the shape parameters of each sector are given in Table 5.)

Table 5 List of estimation methods by sectors

Sector		Useful life	Shape parameter	Estimation method	Initial fiscal year	Definition of investment
1	Road	66 years	2.61	PIM		Public works carried out by national and local governments on roads and streets, and toll roads such as motorways. The amount of actual investment is based on “the Survey of Actual Construction Project Expenditure under the jurisdiction of the Ministry of Land, Infrastructure, Transport and Tourism” , etc.
2	Port and Harbour	47 years	2.5	PIM		Public works carried out by national and local governments on ports and harbours. The amount of actual investment is based on the internal data in each project.
3	Aviation	16 years	2.5	BYM	1953	Covers the capital expenditure in the special account for airport development, the airport portion of civil engineering cost in the ordinary construction project expenditure of local governments, and the capital expenditure in the financial documents of the respective airport companies.
4-1	Railways (Railway Construction, Transport and Technology Agency)	26 years	2.5	PIM		Covers construction and administrative costs excluding the civil railway line-related part of the former Japan Railway Construction Corporation, and the railway-related part of the former Honshu-Shikoku Bridge Authority's construction, survey and general administrative costs.
4-2	Railways (Underground)	33 years	2.5	PIM		Covers the cost of newly constructing of underground, Automated Guideway Transit, monorails, new town lines, etc., and the enhancement and improvement of transport facilities.

Sector		Useful life	Shape parameter	Estimation method	Initial fiscal year	Definition of investment
5	Public housing for rent	62 years	4	BYM	1953	New construction and improvement expenditure in the public rental housing sector is estimated in accordance with data from the “Gross fixed capital formation of public housing” in the System of National Accounts of Japan, excluding disaster recovery expenditure, which is inspected separately.
6	Sewerage	63 years	1.73	BYM	1963	Covers sewerage projects and sewerage end-of-life treatment facility projects undertaken by national and local governments.
7	Waste disposal	23 years	2.88	BYM	1953	Covers the cost of cleaning out of sanitation in the ordinary construction project expenditure of local governments, and the capital expenditure of the Japan Environmental Storage and Safety Corporation.
8	Water supply	65 years	1.69	BYM	1953	Covers the amount of actual investment in water supply projects.
9	Public park	43 years	3	BYM	1963	Urban parks and green space conservation projects are covered.
10-1	Cultural and educational facilities (school and academic facilities)	45 years	4	BYM	1953	Covers the school portion of education expenditure in the ordinary construction project expenditure of local governments, and the facility development expenditure of national and public universities (excluding affiliated hospitals).

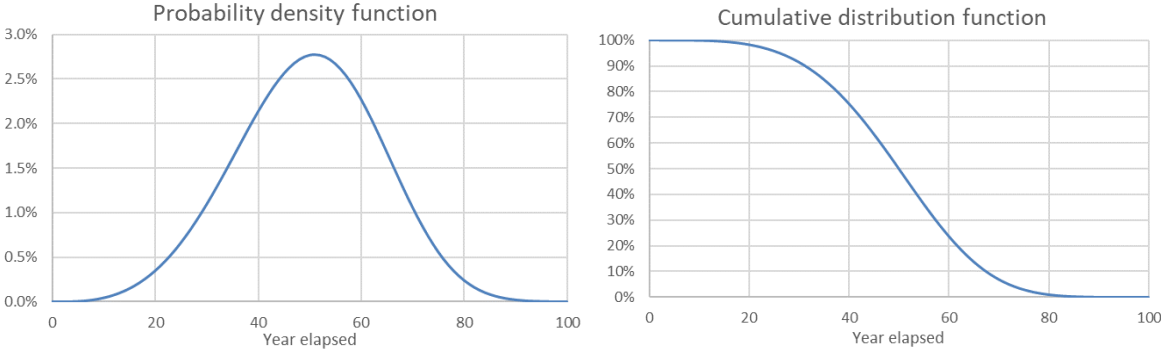
Sector		Useful life	Shape parameter	Estimation method	Initial fiscal year	Definition of investment
10-2	Cultural and educational facilities (social education facilities, social sports facilities, cultural facilities)	45 years	4	BYM	1963	The amount of actual investment in social education facilities, social sports facilities and cultural facilities are surveyed.
11	Flood control	117 years	2.5	BYM	1953	Covers river and erosion control projects undertaken by national and local governments.
12	Forest conservation	44 years	2.5	BYM	1953	The amount of actual investment to forest conservation projects is surveyed.
13	Coast conservation	50 years	2.5	BYM	1953	Covers coast conservation projects undertaken by national and local authorities.
14-1	Primary sector (Agriculture)	45 years	2.5	PIM		Covers agricultural infrastructure projects undertaken by the national government, local governments, land improvement districts and other related organisations, and projects undertaken by the Forest Research and Management Organization.
14-2	Primary sector (Forestry)	40 years	2.5	PIM		Includes production infrastructure development (forest roads, afforestation, living environment development, etc.) and shared-use facility development, excluding national forest areas.
14-3	Primary sector (Fishing)	50 years	2.5	BYM	1953	Covers the fisheries infrastructure projects undertaken by national and local governments.
15	Postal service	18 years	4	BYM	1953	Covers the postal services by Japan Post.

Sector		Useful life	Shape parameter	Estimation method	Initial fiscal year	Definition of investment
16	State forest	41 years	2.5	BYM	1953	Includes the actual amount of investment in production infrastructure projects in national forests (forest roads, afforestation and government-owned afforestation).
17	Industrial water supply	59 years	1.69	BYM	1963	Includes the amount of actual investment in industrial water supply projects.
18	Government building	46 years	4	BYM	1953	Covers public service buildings (non-residential use only) of the national and local governments. Actual investment figures are based on “Statistics on Building Construction Started” and other sources.

The scale parameters have been set so that the cumulative disposal probability (non-disposal rate) is 50% over the average service life.

The values of average useful life have been calculated based on data and research on the actual number of years in service at the time of decommissioning with reference to “the Ministerial Ordinance on the Useful Life of Depreciable Assets” (Ministry of Finance) and have been set by sector (see Table 5).

Figure 2 Shape of disposal distribution



4) Efficiency decline

Assuming that the efficiency of social capital declines due to physical, economic and social degradation, the efficiency decline of social capital was estimated by setting up a pattern of efficiency decline with an upward convex hyperbolic function.



#### 5) Depreciation

Depreciation could be assessed based on market prices for private capital. However, social capital must be assessed in a different way because there is essentially no market transaction. Therefore, in this estimation, depreciation was estimated using the method of present discounted value of the value of capital services obtained from future social capital, which is assumed to be based on the set pattern of efficiency decline.

#### 6) Recontruction cost from natural dissaster

With the concept that all stocks may be damaged when a natural disaster occurs, it is assumed that all stocks are affected and suffer the same level of damage (i.e. are deducted with the same probability), and all stocks existing at the time of the disaster are deducted according to disaster recovery costs. Disaster recovery costs are recorded as investments in the relevant fiscal year, and thus, gross capital stock is not affected. In terms of recovery cost from the Great East Japan Earthquake, the amount of damage caused by the Great East Japan Earthquake is estimated separately and deducted from all stocks that existed at the time of the Great East Japan Earthquake, and no deduction was made according to disaster recovery costs.

#### (4) Methodology of estimating the stock of each prefecture

In this estimation, the national investment was proportionally divided by prefecture using the “Administrative Investment Outcome” (Ministry of Internal Affairs and Communications), and the BYM was applied to each prefecture to estimate the stock by prefecture as a reference value. Because there are no statistics on investment by prefecture for railways and post in the “Administrative Investment Results,” 16 sectors excluding railways and post were included in the estimation.

The initial fiscal year of the base stock was 1960, and the sectoral stock by prefecture for 1960 was estimated by proportionally prorating the sectoral stock on a national basis according to the proportion of stock by prefecture by the General Planning Bureau of the Economic Planning Agency in 1968.

The nature of the investment in “The Administrative investment results” used for prorating investment differs in some respects from the investment in this estimation. This is because the “Administrative Investment Results” includes land, compensation, maintenance and repair costs, and capital subsidies to the private sector, and that the scope of public enterprises covered by them is different. However, according to the estimation by using “The Statistics on Construction Operations” (Ministry of Land, Infrastructure, Transport and Tourism) and

“The Survey of Actual Construction Investment under the Ministry of Land, Infrastructure, Transport and Tourism” (Ministry of Land, Infrastructure, Transport and Tourism), which provide information on investment by sector, it was implied that there was significant discrepancy in the estimation due to the difference between them. Therefore, it was decided to continue to estimate proportionally using “The Administrative Investment Results.”

## 2. Summary of estimation

Estimates of all 18 sectors are shown in Table 6. The gross capital stock has continued to increase gradually in recent years, while the net capital stock has remained almost unchanged in recent years.

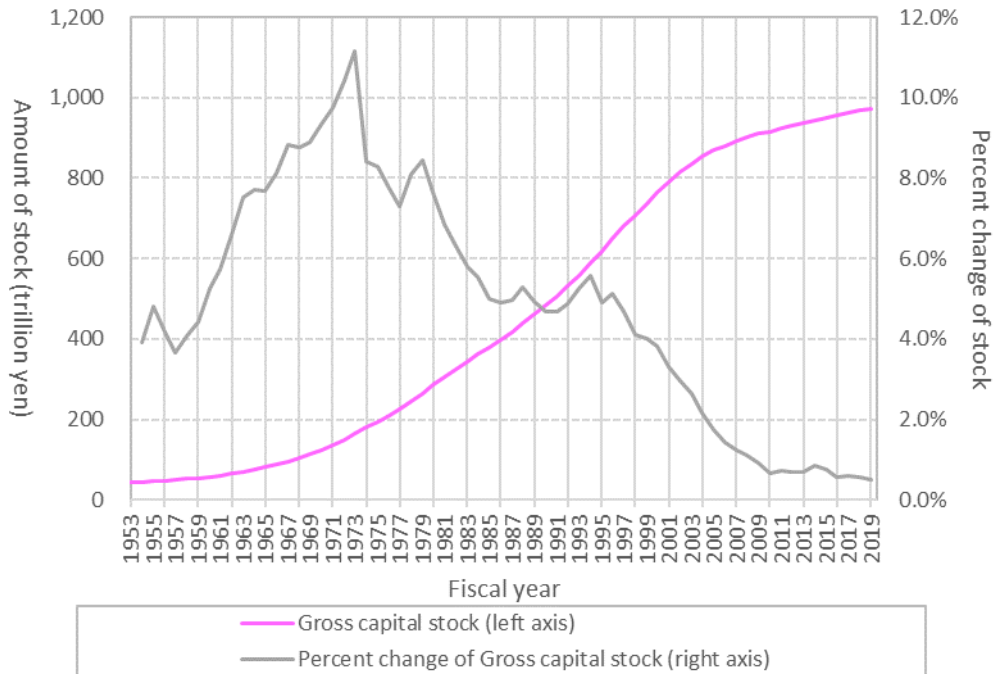
Table 6 The result of the estimates of all 18 sectors  
(reference year of deflator: 2015)

Type of stock	Gross capital stock	Net capital stock	Productive capital stock
Amount of Stock (2019FY) (Total of 18 sectors, Nationwide)	972 trillion yen	641 trillion yen	796 trillion yen

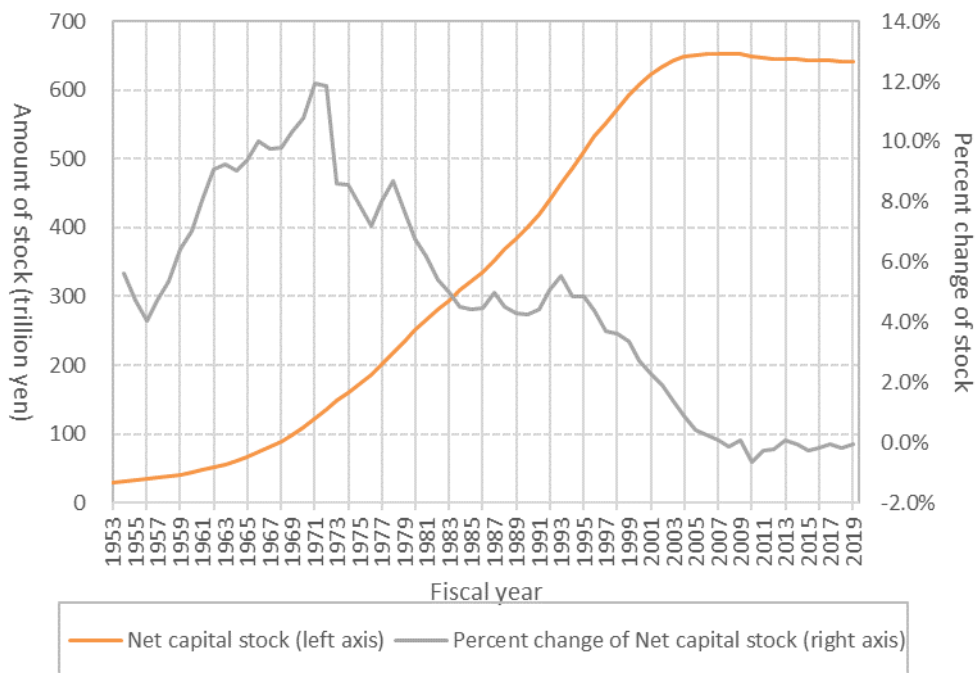
Note: Figures are in real terms (2015 calendar year prices = 100), calculated by chain-integration of 18 sectors.

Figure 3 Transition of stock of all 18 sectors (reference year of deflator: 2015)

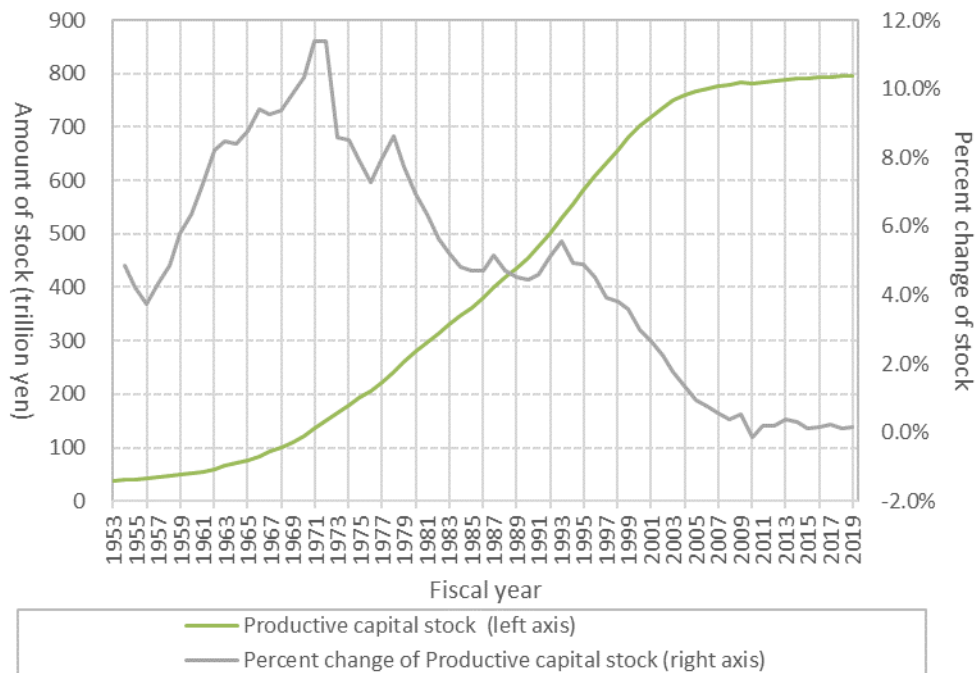
(Gross capital stock)



(Net capital stock)



(Productive capital stock)



(1) The result of the stock estimation by sectors

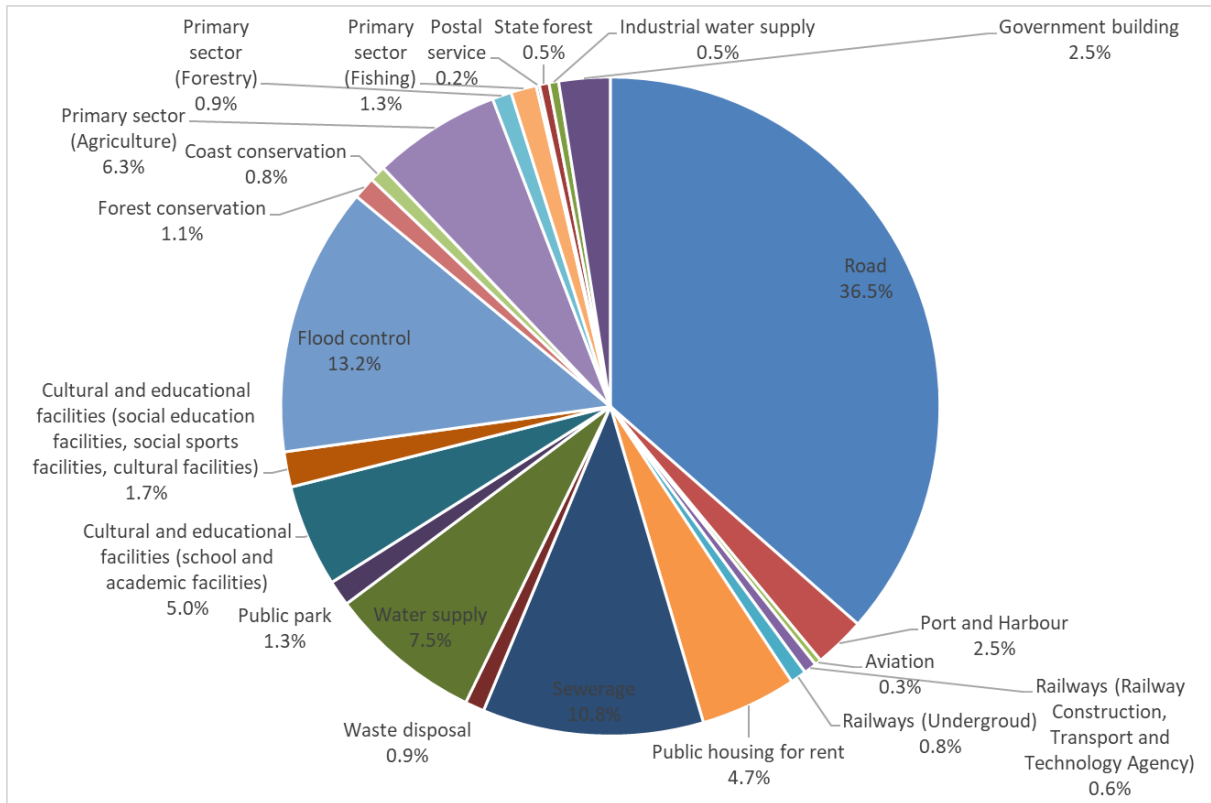
The result of the estimates by sectors are in Table 7. A breakdown of the nominal value of the net capital stock in Figure 4 shows that roads accounted for the highest proportion with 36.5%, followed by flood control (13.2%), sewerage (10.9%), water supply (7.7%) and primary sector (agriculture) (6.3%).

Table 7 Result of the estimates by sectors (2019FY)  
(reference year of deflator: 2015) [trillion yen]

Type of stock		Gross capital stock	Net capital stock	Productive capital stock
Total of 18 sectors		972	641	796
1	Road	324	232	277
2	Port and Harbour	29	16	22
3	Aviation	5	2	3
4-1	Railways (Railway Construction, Transport and Technology Agency)	7	4	6
4-2	Railways (Undergroud)	11	5	7
5	Public housing for rent	54	30	42
6	Sewerage	99	69	84
7	Waste disposal	15	6	10
8	Water supply	65	48	56
9	Public park	15	8	11
10-1	Cultural and educational facilities (school and academic facilities)	60	32	46
10-2	Cultural and educational facilities (social education facilities, social sports facilities, cultural facilities)	23	11	16
11	Flood control	105	84	94
12	Forest conservation	13	7	10
13	Coast conservation	8	5	6
14-1	Primary sector (Agriculture)	76	40	55
14-2	Primary sector (Forestry)	12	6	9
14-3	Primary sector (Fishing)	14	8	11
15	Postal service	1	1	1
16	State forest	6	3	4
17	Industrial water supply	4	3	3
18	Government building	30	16	23

Note: Figures are in real terms (2015 calendar year prices = 100)

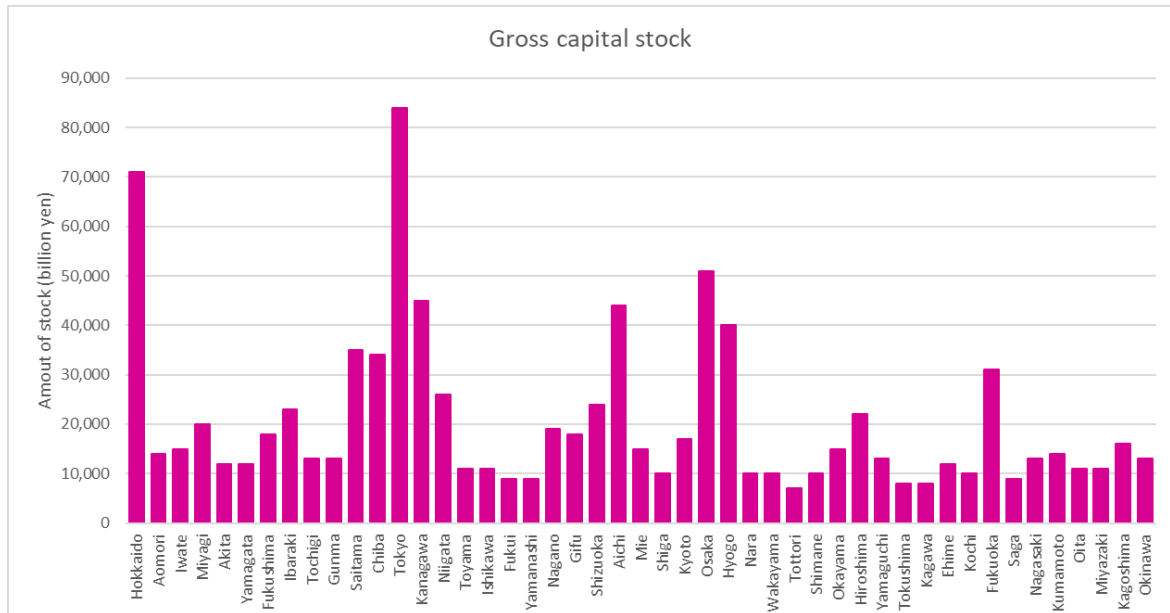
Figure 4 Net capital stock by sectors (Nominal, 2019FY)



(2) Result of the estimates by Prefectures (16 sectors)

Result of the estimates by Prefectures are shown in Figure 5 and Table 8.

Figure 5 Gross capital stock by prefectures (2019FY)  
(reference year of deflator: 2015)



Note: Figures are in real terms (2015 calendar year prices = 100)

Total of 16 sectors excluding postal service and Railways.

Table 8 The result of the estimates by Prefectures (2019FY)  
(reference year of deflator: 2015)

Total of 16 sectors	Gross capital stock	Net capital stock	Productive capital stock	Total of 16 sectors	Gross capital stock	Net capital stock	Productive capital stock
<b>Nationalwide</b>	<b>972</b>	<b>641</b>	<b>796</b>				
Hokkaido	71	47	58	Shiga	10	7	8
Aomori	14	9	11	Kyoto	17	11	14
Iwate	15	11	13	Osaka	51	32	41
Miyagi	20	15	18	Hyogo	40	25	32
Akita	12	8	10	Nara	10	7	8
Yamagata	12	8	10	Wakayama	10	7	8
Fukushima	18	12	15	Tottori	7	5	6
Ibaraki	23	15	19	Shimane	10	7	8
Tochigi	13	9	11	Okayama	15	9	12
Gunma	13	9	11	Hiroshima	22	14	18
Saitama	35	24	29	Yamaguchi	13	8	10
Chiba	34	22	28	Tokushima	8	6	7
Tokyo	84	54	69	Kagawa	8	5	6
Kanagawa	45	29	36	Ehime	12	8	10
Niigata	26	17	21	Kochi	10	7	8
Toyama	11	7	9	Fukuoka	31	20	25
Ishikawa	11	7	9	Saga	9	6	7
Fukui	9	6	7	Nagasaki	13	8	11
Yamanashi	9	6	7	Kumamoto	14	9	12
Nagano	19	13	16	Oita	11	7	9
Gifu	18	12	15	Miyazaki	11	7	9
Shizuoka	24	16	20	Kagoshima	16	11	13
Aichi	44	28	36	Okinawa	13	8	10
Mie	15	10	12				

Note: Figures are in real terms (2015 calendar year prices = 100)

Total of 16 sectors excluding postal service and Railways.