

Summary of Methodology for Estimating Stock of Infrastructure in Japan and Estimation Outcomes. (Measuring Infrastructure in Japan 2023)

1. Summary of methodology for estimation

(1) Sectors to be estimated

The sectors covered in this estimation are the following 17 sectors where operators are public institutions in a narrow sense with the condition that continuous data is available.

Table 1 17 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	State forest
9	Public park	16	Industrial water supply
		17	Government building

(2) Types and definitions of stock

Gross capital stock, productive capital stock, and net 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

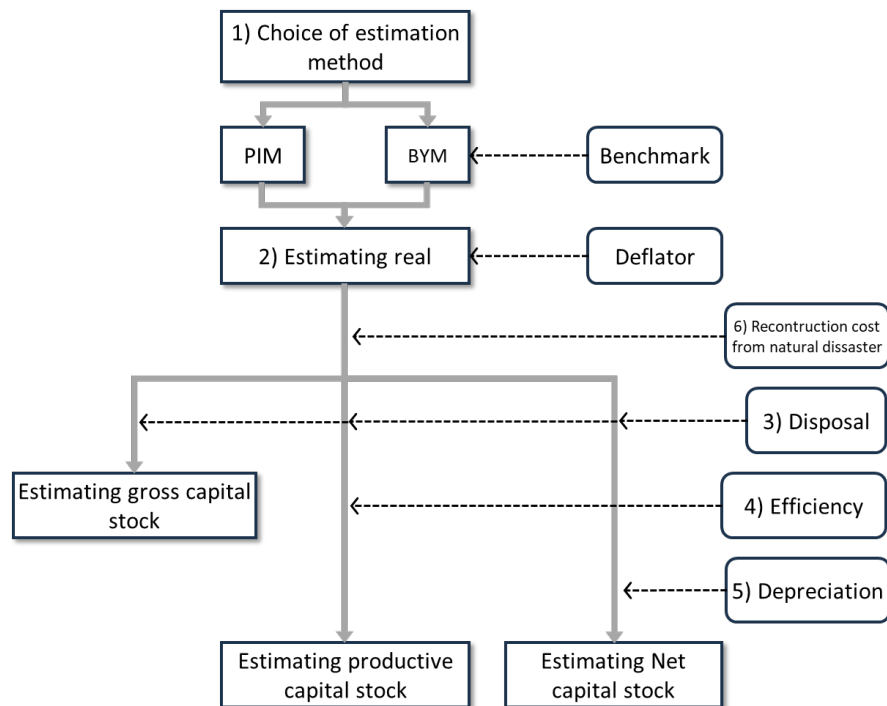
Gross capital stock	Asset endowment. Value of existing fixed assets assessed by their acquisition price (investment value).
Productive capital stock	The value of the gross capital stock less efficiency losses (reduction in capacity to produce services) over the years of use.
Net capital stock	The value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

(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 productive capital stock by deducting the efficiency losses and the net capital stock can then be obtained by deducting the age-related depreciation. 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 (Undergroud), 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), 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), 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

η : 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	58 years	1.66	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)	32 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	61 years	2.00	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	64 years	1.81	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	68 years	1.71	BYM	1953	Covers the amount of actual investment in water supply projects.
9	Public park	42 years	3	BYM	1963	Urban parks and green space conservation projects are covered.
10-1	Cultural and educational facilities (school and academic facilities)	42 years	2.61	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).

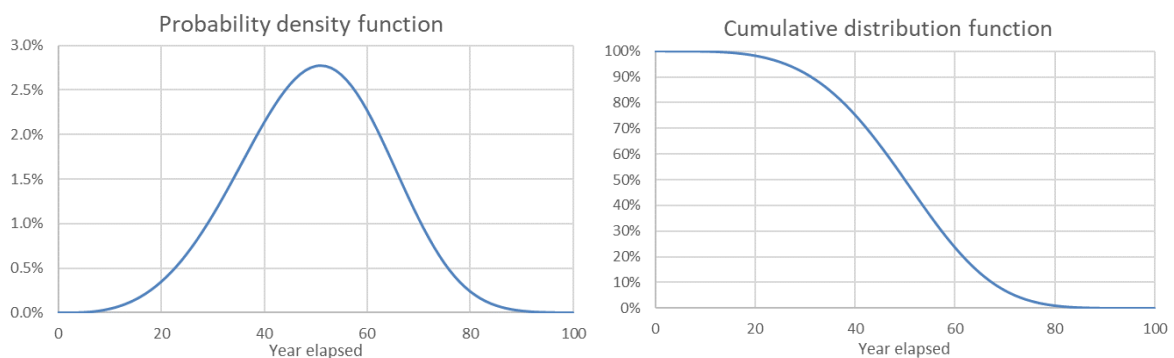
Sector		Useful life	Shape parameter	Estimation method	Initial fiscal year	Definition of investment
10-2	Cultural and educational facilities (social education facilities, social sports facilities, cultural facilities)	40 years	4	BYM	1963	The amount of actual investment in social education facilities, social sports facilities and cultural facilities are surveyed.
11	Flood control	107 years	1.65	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)	44 years	2.20	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.

Sector		Useful life	Shape parameter	Estimation method	Initial fiscal year	Definition of investment
15	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).
16	Industrial water supply	65 years	1.82	BYM	1963	Includes the amount of actual investment in industrial water supply projects.
17	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) Reconstruction cost from natural disaster

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 in the “Administrative Investment Results,” 16 sectors excluding railways 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

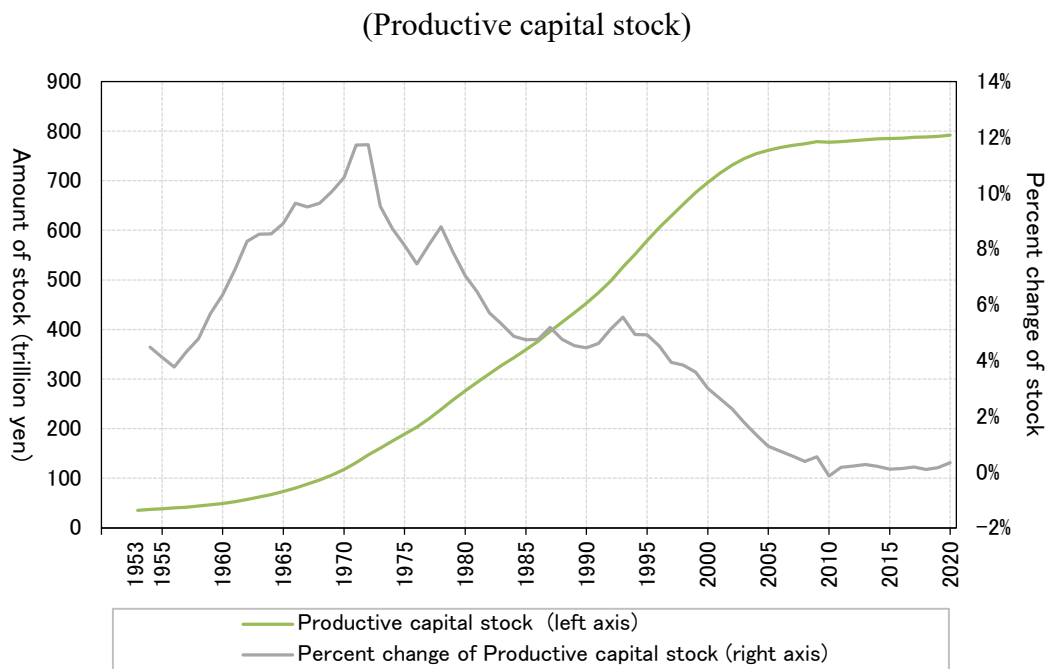
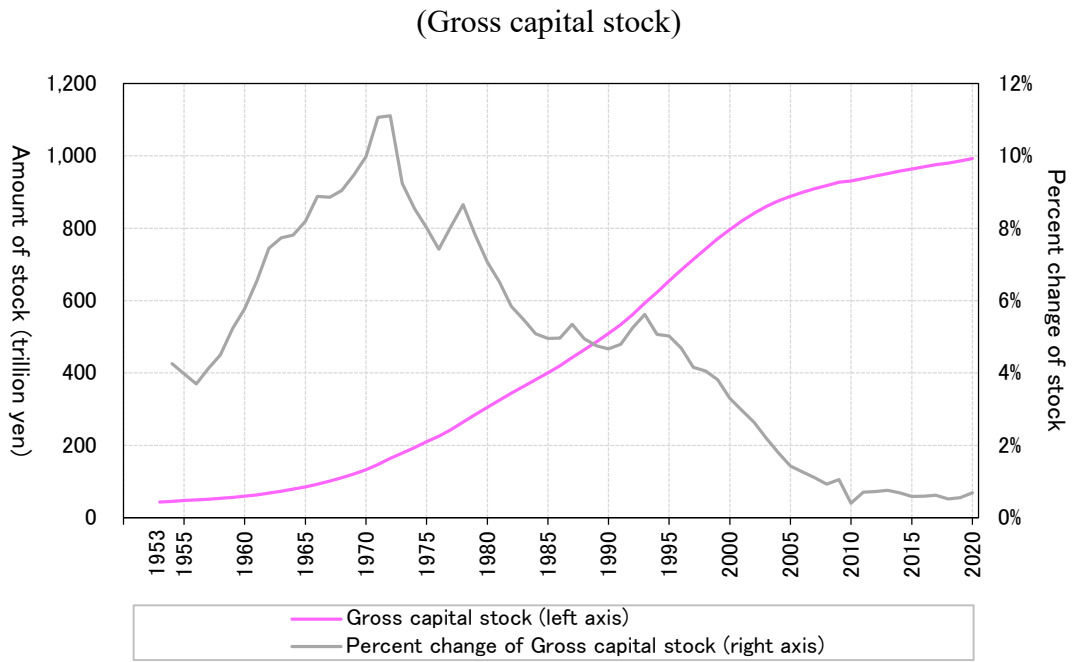
Estimates of all 17 sectors are shown in Table 6. The gross capital stock has continued to increase gradually in recent years, while the net capital stock has remained almost unchanged in recent years.

Table 6 The result of the estimates of all 17 sectors
(reference year of deflator: 2015)

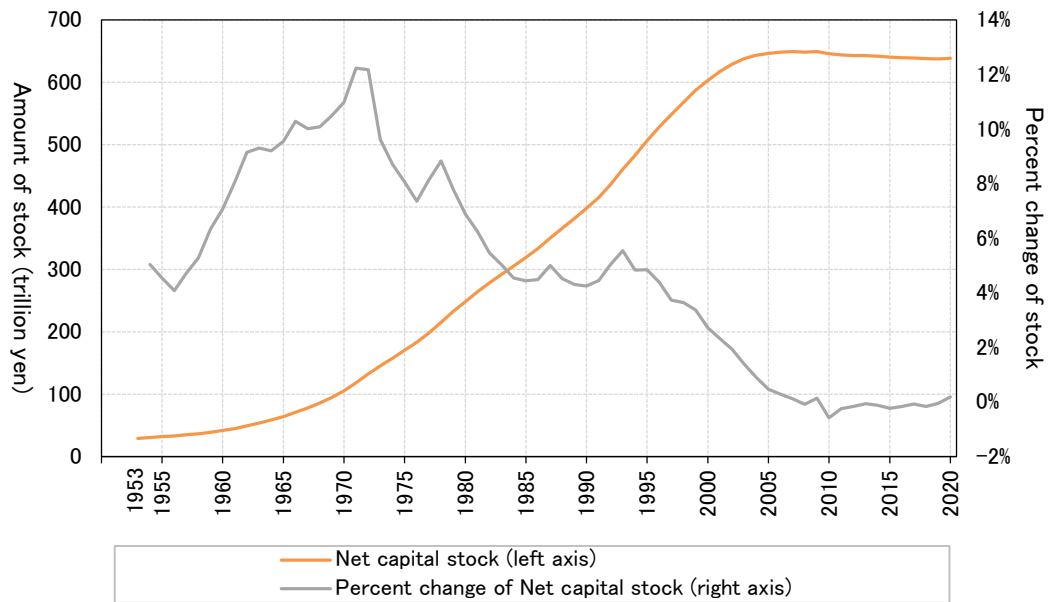
Type of stock	Gross capital stock	Productive capital stock	Net capital stock
Amount of Stock (2020FY) (Total of 17 sectors, Nationwide)	993 trillion yen	792 trillion yen	639 trillion yen

Note: Figures are in real terms (2015 calendar year prices = 100), calculated by chain-integration of 17 sectors.

Figure 3 Transition of stock of all 17 sectors (reference year of deflator: 2015)



(Net capital stock)



(1) The result of the stock estimation by sectors

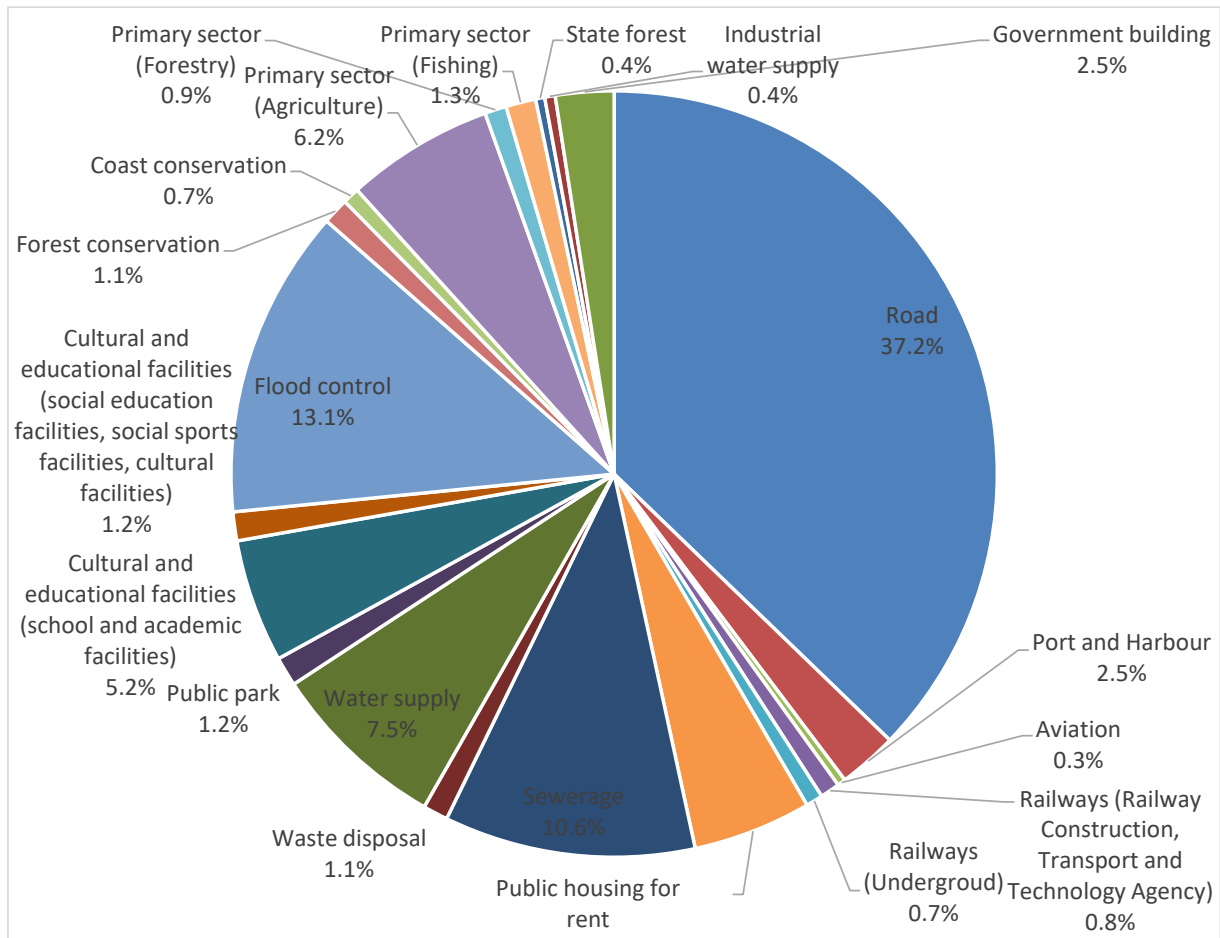
The result of the estimates by sectors are in Table 7. A breakdown of the nominal value of the net capital stock in Figure 4 shows that roads accounted for the highest proportion with 37.2%, followed by flood control (13.1%), sewerage (10.6%), water supply (7.5%) and primary sector (agriculture) (6.2%).

Table 7 Result of the estimates by sectors (2020FY)
(reference year of deflator: 2015) [trillion yen]

Type of stock		Gross capital stock	Productive capital stock	Net capital stock
Total of 17 sectors		993	792	639
1	Road	338	282	237
2	Port and Harbour	29	21	16
3	Aviation	5	3	2
4-1	Railways (Railway Construction, Transport and Technology Agency)	10	7	5
4-2	Railways (Underground)	10	7	5
5	Public housing for rent	50	39	32
6	Sewerage	101	83	68
7	Waste disposal	15	10	7
8	Water supply	67	56	48
9	Public park	15	11	8
10-1	Cultural and educational facilities (school and academic facilities)	68	49	34
10-2	Cultural and educational facilities (social education facilities, social sports facilities, cultural facilities)	18	12	8
11	Flood control	107	93	83
12	Forest conservation	13	10	7
13	Coast conservation	8	6	5
14-1	Primary sector (Agriculture)	74	53	40
14-2	Primary sector (Forestry)	12	8	6
14-3	Primary sector (Fishing)	14	11	8
15	State forest	6	4	2
16	Industrial water supply	4	3	3
17	Government building	31	23	16

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

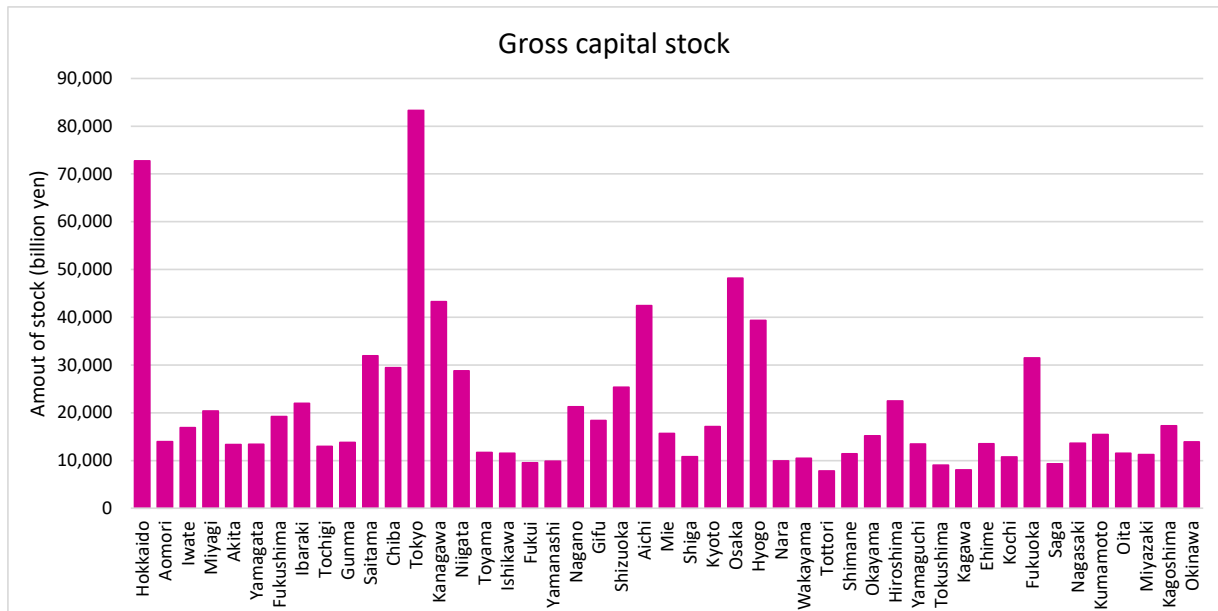
Figure 4 Net capital stock by sectors (Nominal, 2020FY)



(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 (2020FY)
(reference year of deflator: 2015)



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

Total of 16 sectors excluding Railways.

Table 8 The result of the estimates by Prefectures (2020FY)
(reference year of deflator: 2015)

Total of 16 sectors	Gross capital stock	Productive capital stock	Net capital stock	Total of 16 sectors	Gross capital stock	Productive capital stock	Net capital stock
Nationalwide	973	778	629				
Hokkaido	73	58	47	Shiga	11	9	7
Aomori	14	11	9	Kyoto	17	14	11
Iwate	17	14	11	Osaka	48	38	30
Miyagi	20	17	14	Hyogo	39	31	25
Akita	13	11	9	Nara	10	8	6
Yamagata	13	11	9	Wakayama	10	9	7
Fukushima	19	16	13	Tottori	8	6	5
Ibaraki	22	18	14	Shimane	11	9	8
Tochigi	13	10	8	Okayama	15	12	10
Gunma	14	11	9	Hiroshima	22	18	14
Saitama	32	26	21	Yamaguchi	13	11	9
Chiba	29	23	19	Tokushima	9	7	6
Tokyo	83	66	53	Kagawa	8	6	5
Kanagawa	43	34	28	Ehime	14	11	9
Niigata	29	23	19	Kochi	11	9	7
Toyama	12	9	8	Fukuoka	31	25	21
Ishikawa	12	9	7	Saga	9	7	6
Fukui	10	8	6	Nagasaki	14	11	9
Yamanashi	10	8	6	Kumamoto	15	12	10
Nagano	21	17	14	Oita	12	9	7
Gifu	18	15	12	Miyazaki	11	9	7
Shizuoka	25	20	16	Kagoshima	17	14	11
Aichi	42	34	27	Okinawa	14	11	9
Mie	16	13	10				

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

Total of 16 sectors excluding Railways.