Hitotsubashi Workshop on Economic Measurement

Constructing Building Price Index Using Administrative Data

-A Method for Estimating an Output-type Building Price Index Using Individual Data from the Statistics on Building Starts-

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1. Motivations

Construction investment as Capital Stock

Construction investment is counted as ***gross fixed capital formation*** **and increases** ***the capital stock***.

- Compared to machinery and equipment, its **share in the capital stock** is extremely **high** due to its **long useful life**.

- The construction price index has a significant impact on
  - ***GDP***
  - ***fixed capital depreciation***
  - ***productivity (TFP)***

The Construction Sector in Japan

- High share of the construction industry in GDP **(12%)**
- High impact of the construction investment share in the capital stock.

(Construction investment in 2019, Total GDP: 557 trillion yen)

Subject property	private	public	Total
Housing	19.3 trillion yen (28%)	0.3 trillion yen (0%)	19.6 trillion yen (28%)
Non-housing building	11.8 trillion yen (17%)	2.8 trillion yen (4%)	14.6 trillion yen (21%)
Building Repair	10.1 trillion yen (15%)	1.8 trillion yen (3%)	11.8 trillion yen (17%)
Public works	6.7 trillion yen (10%)	16.3 trillion yen (24%)	23.0 trillion yen (33%)
Total	47.9 trillion yen (69%)	21.2 trillion yen (31%)	69.0 trillion yen (100%)

Price index used as a deflator

The price index used as a deflator must **MATCH** the nominal amount and parity with respect to the coverage.

Nominal amount	Price index
Value of output /shipments	at the producer stage (corporate price index and service price index)
Value of household consumption expenditure	at the consumer purchase stage (consumer price index)
Value of buildings	**"input cost-type"** construction price index

Input/output structure of the construction industry: 2017

Appropriate range of price index

Total value of output: JPY 65.0 trillion

Medium input:

34.9 trillion yen

54%

Labour costs

20.5 trillion.

32%

Operating surplus, mixed income, depreciation of fixed assets, taxes, etc.

9.6 trillion

14%

Range covered by "input cost-type" construction price index

WHY are construction prices difficult to be measured?

Highly heterogeneity problem

Buildings and civil engineering structures are *completely custom-made products*.

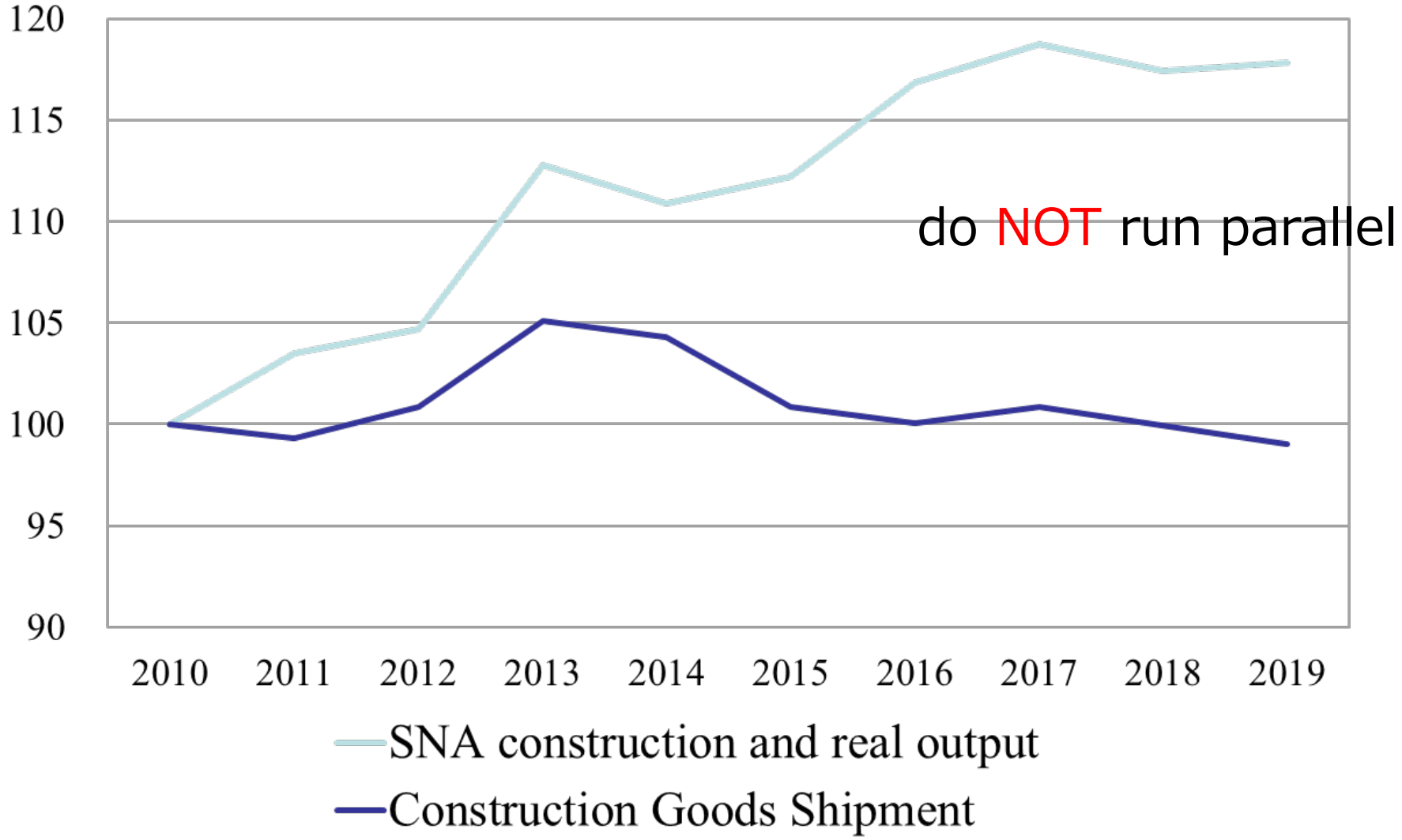
Quality adjustment problem

It is not possible to continuously observe changes in market transaction prices.

Data availability problem

Market data are difficult to be collected.

Real output of construction and construction goods shipments



2. “Output-Type” Construction Price Indices

“Output –type” price index

OECD (1997) introduces the following six methods to construct a price index:

(1) Model price method

(2) Quoted prices method

(3) List prices method

(4) Matched models method

(5) Stratification method

(6) Hedonic method

Problems with the "Model pricing approach" *in Japan*

The COST of producing statistics by "model pricing approach" is HIGH in Japan.

- To secure ***personnel with construction expertise*** in the statistics department to design the model is quite difficult (scarce resource).
- For construction companies, ***reporting hypothetical prices*** every month is heavy task.

3. Estimation

Indexes to be created

Six indexes:

- Housing buildings (wooden, Reinforced Concrete[RC], Steel-framed)
- Non-housing buildings (wooden, Reinforced Concrete[RC], Steel-framed)

Frequency: quarterly (averages)

Data

"Building Construction Notification"

- Under the Building Standard Law, the building owner is required to a notification to the prefectural governor when constructing a building (10 m^2 or more).

Estimation period: January 2005 to December 2020

Sample size:7.92 million buildings

Attribute information: estimated construction cost of the building, the building owner, structure, use, type of construction, number of floors above and below ground, and floor area.

	attribute (specification) item	contents
Housing	Building method	Prefabricated, two -by-four, other (conventional construction method)
	Building (e.g., house)	Single-family houses, row houses, and apartment buildings
	Structure	Wooden construction, steel -framed reinforced concrete construction, reinforced concrete construction, steel construction, and concrete block construction, among others
	Administrative divisions of Japan	47 Prefectures
	Usage restrictions, limitations	Owner-occupied houses, rental houses, salaried housing, and condominiums
Non-housing	Versatile or not	Multi-purpose buildings, among others
	Purpose	Standard Industrial Classification (Middle Classification)
	Structure	Wooden construction, steel -framed reinforced concrete construction, reinforced concrete construction, steel construction, and concrete block construction, among others
	Administrative divisions of Japan	47 Prefectures

Two approaches

Stratification Approach

Building method	Structure	Housing Type	Prefecture	Usage restrictions, limitations	…	…	Jan-10	Feb-10	Mar-10	Apr-10	May-10	…
Prefabricated construction method	Wooden structure	Single-family houses	Hokkaido	Owner-occupied house	…	…	20.27	19.73	20.98	19.69	19.81	…
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Prefabricated construction method	Reinforced concrete structure	Single-family houses	Tokyo	Owner-occupied house	…	…	25.97	24.82	24.36	24.82	26.56	…
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Frame wall construction method	Wooden structure	Apartment houses	Fukuoka	Rental house	…	…	10.97	11.90	12.92	11.91	11.85	…
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Hedonic approach

$$\log p_i = \alpha + \sum_{j=1}^{n} \beta_j x_{i,j} + \sum_{k=1}^{m} \delta_k d_{i,k} + \sum_{t=1}^{T} \gamma_t TD_{i,t} + u_i$$

Stratification approach

This approach follows four steps below:

1. The data is **classified** based on attributes such as building structure, construction method, region, and use (= procedure called "**stratification**")
2. For each subdivided strata, **the estimated construction cost per floor space** is calculated.
3. Unit cost above is **indexed by FY 2011 = 100**, and individual indexes are created for each strata.
4. The individual indexes for each tier are **weighted and averaged** to create price indexes for the upper tiers (residential wooden structures, residential steel-framed structures, etc.).

Hedonic approach

$$\log p_i = \alpha + \sum_{j=1}^{n} \beta_j x_{i,j} + \sum_{k=2}^{m} \delta_k d_{i,k} + \sum_{t=2}^{T} \gamma_t TD_{i,t} + u_i$$

p_i : square meter unit price of building$i$
α: constant term
$x_{i,j}$: the jth attribute (numeric) of building i
β_j : numerical data parameter
$d_{i,k}$: kth attribute (dummy) of building i
δ_k: dummy variable parameter
$TD_{i,t}$: survey month t of building i (time dummy)
γ_t : parameter of the time dummy(representing quality-adjusted prices)
u_i : error term

Hedonic approach

Estimation method:

Rolling estimation with staggered 12-month windows

(a total of 181 estimates are made over the 192-month)

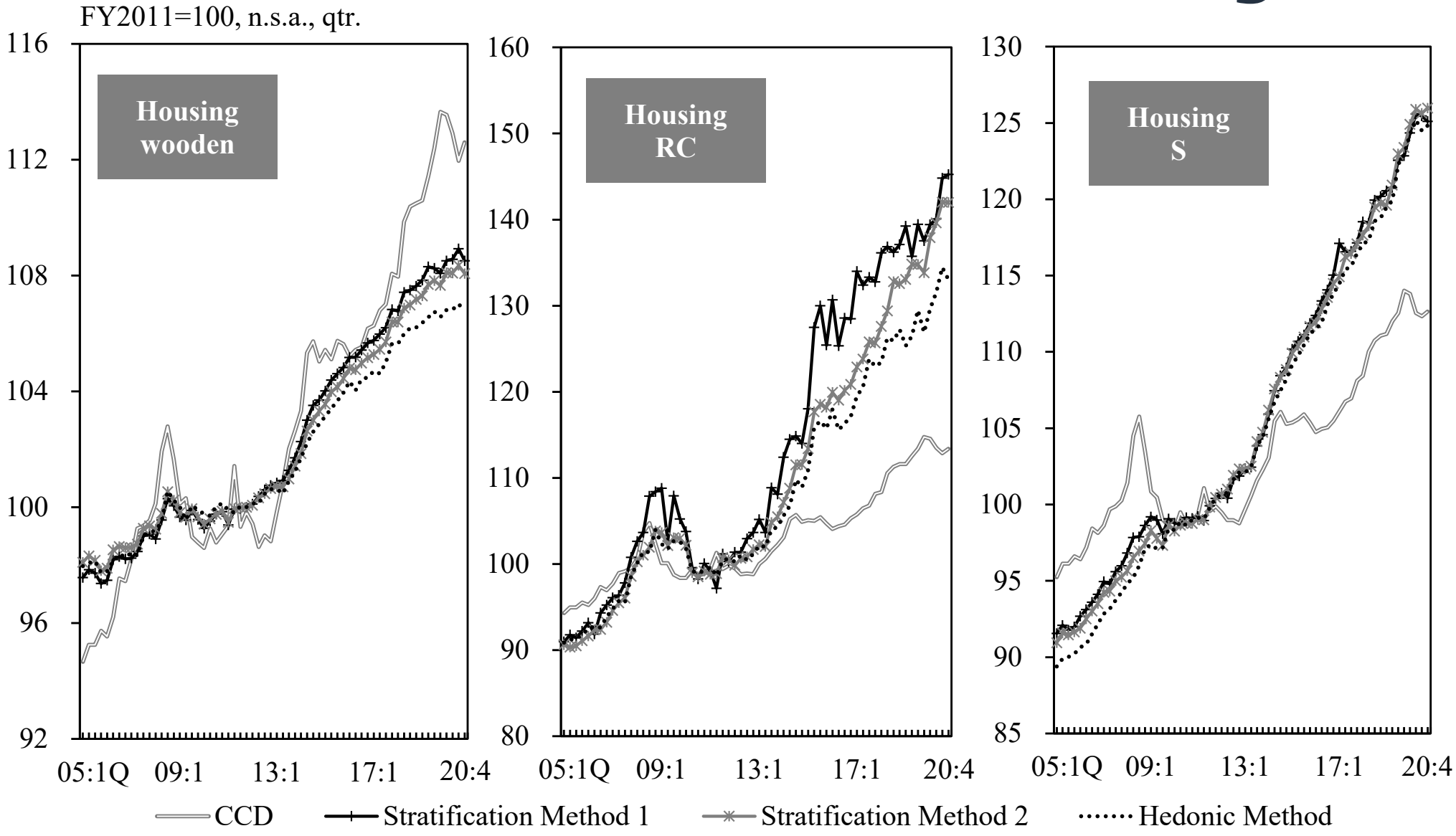
- Same method used in the “Property Price Index" of the *Ministry of Land, Infrastructure, Transport and Tourism*.

Estimation results in Hedonic Regression

			Adj. R^2				Number of Obs.			
			Min.	Max.	Ave.	Med.	Min.	Max.	Ave.	Med.
Housing	Wooden		0.154	0.179	0.167	0.166	317,311	424,311	375,686	375,116
Housing	Non-Wooden	RC	0.250	0.414	0.314	0.312	6,534	18,581	10,307	9,219
Housing	Non-Wooden	S	0.197	0.298	0.253	0.264	39,063	82,629	58,796	57,874
Housing	Non-Wooden	Others	0.100	0.372	0.208	0.201	966	1,659	1,234	1,193
Non-Housing	Wooden		0.143	0.337	0.259	0.267	13,759	18,087	15,574	15,580
Non-Housing	Non-Wooden	RC	0.079	0.205	0.131	0.129	2,234	4,607	3,082	3,055
Non-Housing	Non-Wooden	S	0.230	0.368	0.294	0.291	21,539	40,179	28,777	27,986
Non-Housing	Non-Wooden	Others	0.331	0.514	0.410	0.409	1,170	1,815	1,447	1,412

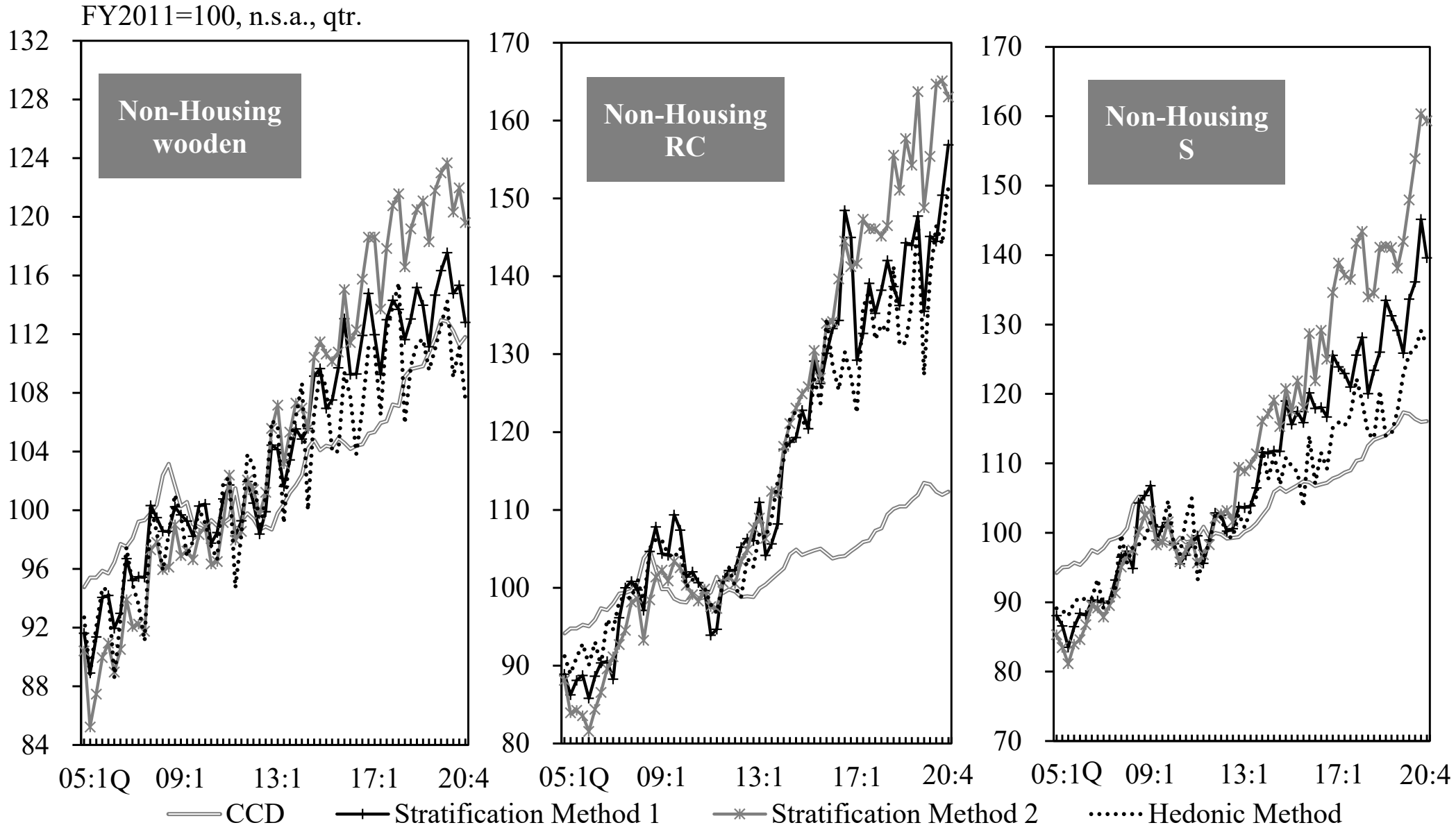
Note: These values are taken for 181 rolling estimaion results.
Source: Estimation by Authors

Baseline estimation results: Housing



Note: Stratified Approach 1 and 2 are weighted by "estimated construction cost" and "number of construction projects," respectively.

Baseline estimation results: non-housing



Housing/ Non-housing	Structure	Stratification v.s. CCD	Hedonic v.s. CCD	Stratification v.s. Hedonic
Housing	wooden	medium gap	medium gap	medium gap
	reinforced concrete construction	large gap	large gap	large gap
	steel construction	medium gap	medium gap	small gap
Non-housing	wooden	large gap	medium gap	large gap
	reinforced concrete construction	large gap	large gap	small gap
	steel construction	large gap	medium gap	large gap

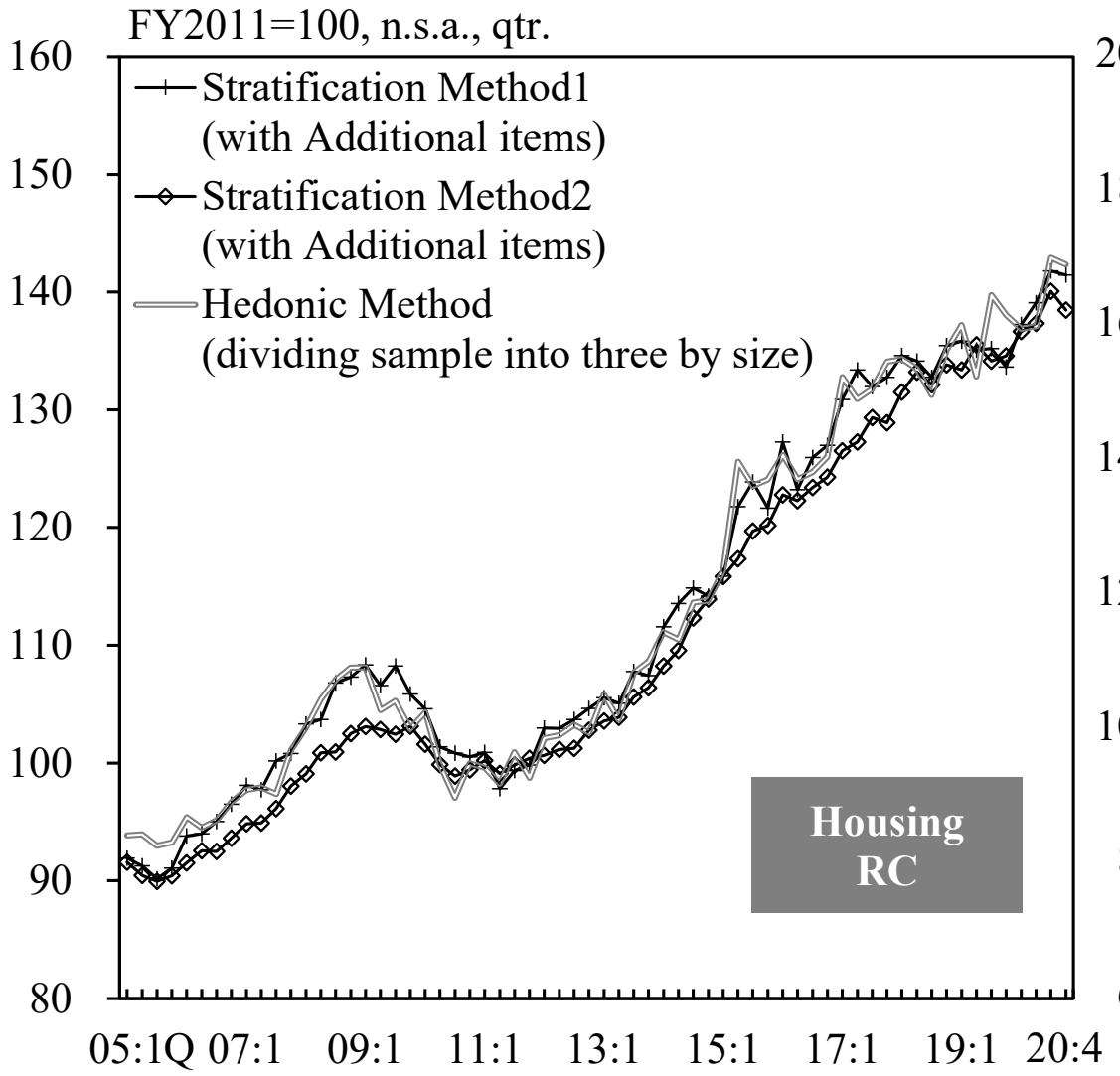
Expanded Models

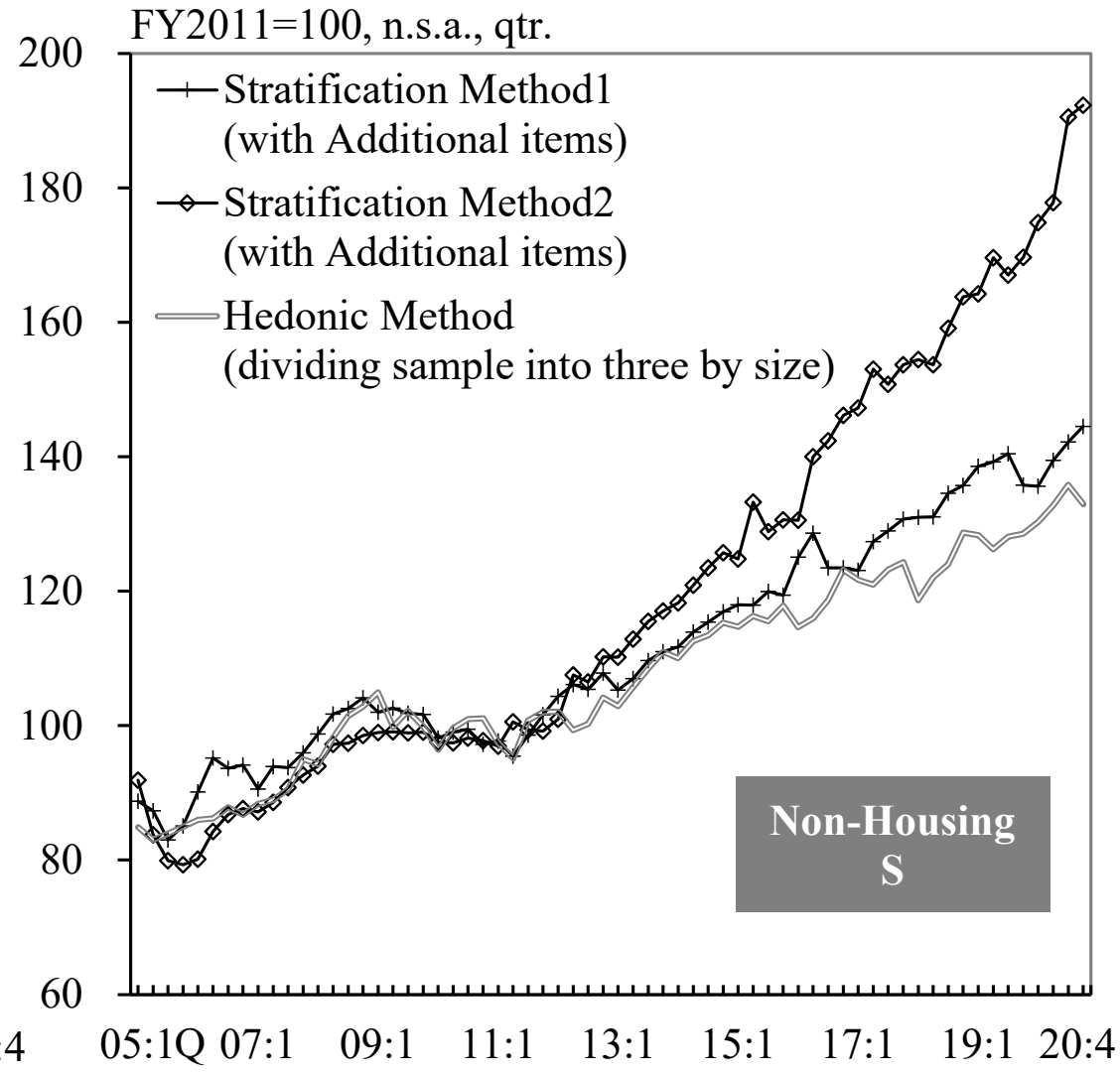
Additional Items in the Stratification Method

The stratification approach was refined **by adding stratification items**, and the hedonic approach was refined **by dividing the sample by building size and adding dummy variables**.

	Baseline	Addition of stratification and subdivision items
Housing	Building method, construction method, structure, prefecture, and use relationship	Baseline; Builder, capitalization category, city planning category, basement, retired housing, funds for new housing, use (building with housing industrial use)
Non-housing	Multi-use or not, use, structure, and prefecture	Baseline; Architect, capitalization category, city planning category, underground

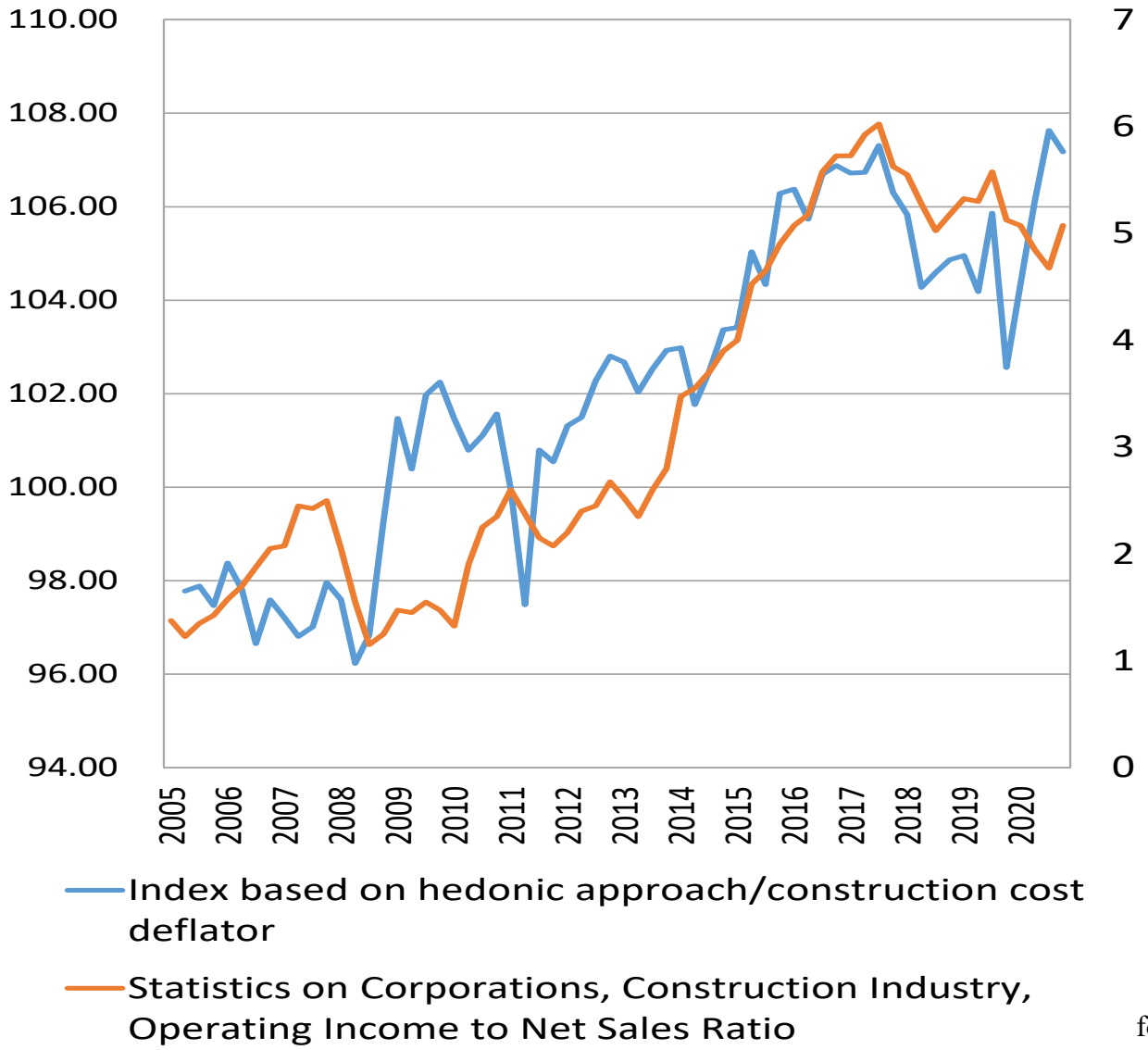
Expanded Models





4. Estimated “Output-Type” Building Price Index

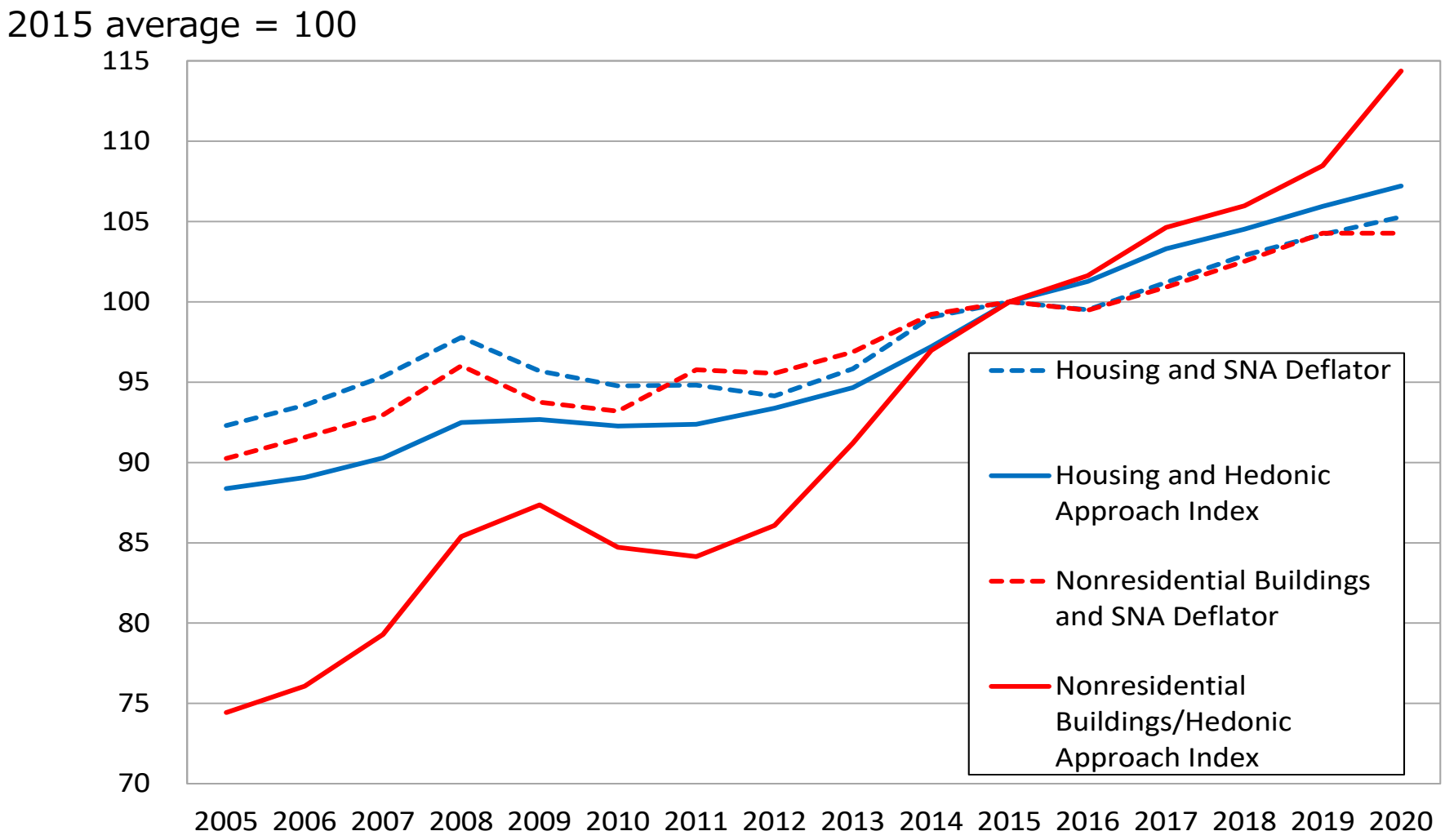
“Output-type" Building Price Index



Hedonic index and operating income of construction industry go parallel.

（Note: Operating income to net sales (right scale: %) is a backward-looking four-period moving average.
（Source: Corporate Statistics, Ministry of Finance

Impact on price index and deflator



5. Conclusion

What “output-type” building price indexes *can* do?

An “output-type” building price index based on the stratification and hedonic approaches **can capture “cyclical price changes reflecting profit changes in the construction sector”** that cannot be captured by an “input cost-type” index.

Consistent with movements in investment (GDP) and TFP.

->Price indexes are useful for economic analysis.

What “output-type” building price indexes *cannot* do?

“Output-type” building price indexes based on the stratification and hedonic approaches ***cannot capture changes in building quality*** (seismic strength, building grade such as interior, and quality improvement through design and facility improvement) that are not covered by the survey items of the “Statistics on Building Construction Starts”.

It is difficult to capture mid- to long-term ***quality improvement***.

Future Works

- In the long run, it is necessary to construct a database that can capture quality improvement.

- The possibility that the soaring construction prices was metropolitan-area specific phenomenon was pointed out. For verification, it is necessary to estimate indexes for each region. If it is true, then hedonic estimation for metropolitan-area (apartments and offices in Tokyo) will be conducted with more detailed attributes data.